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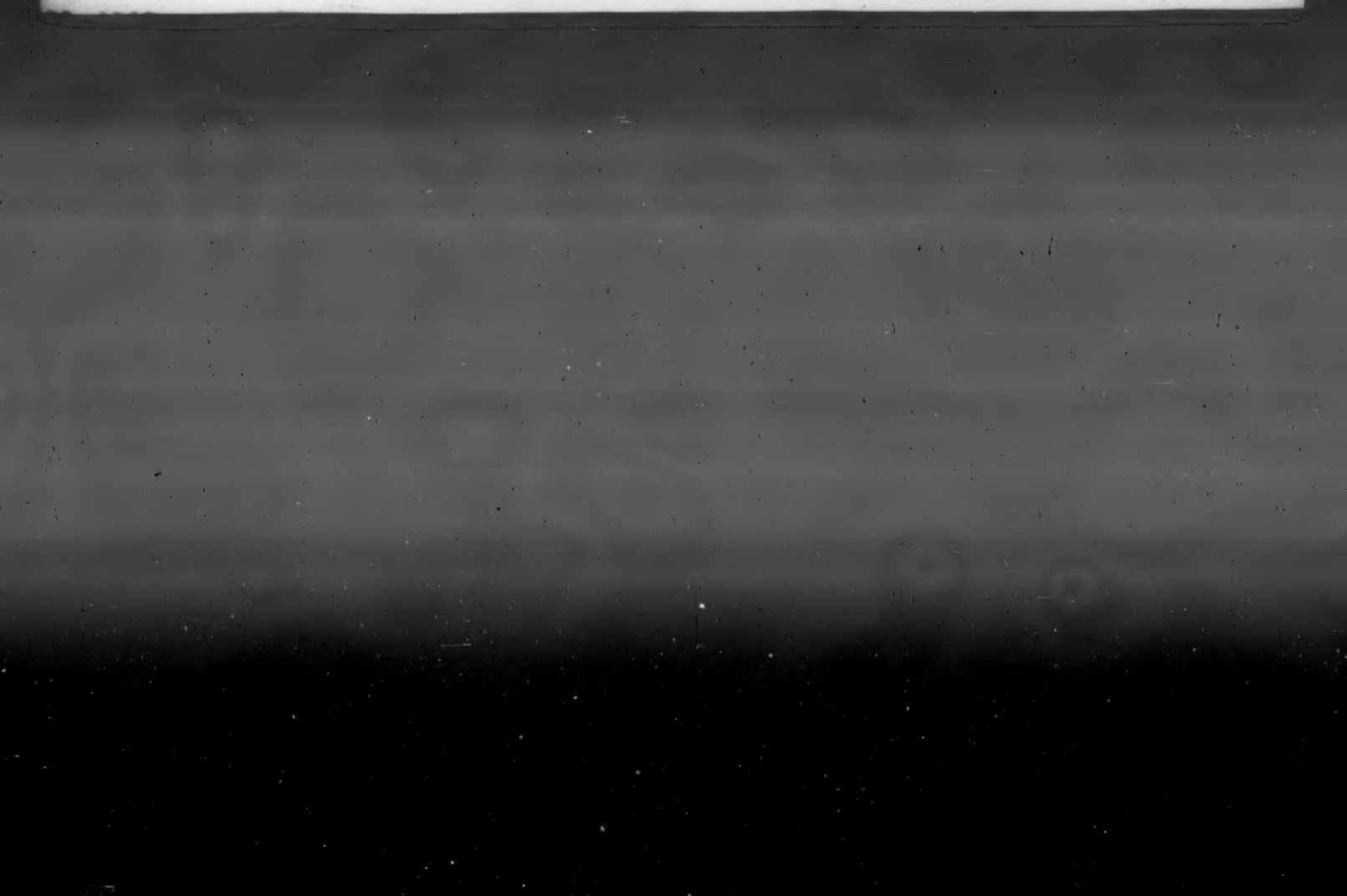

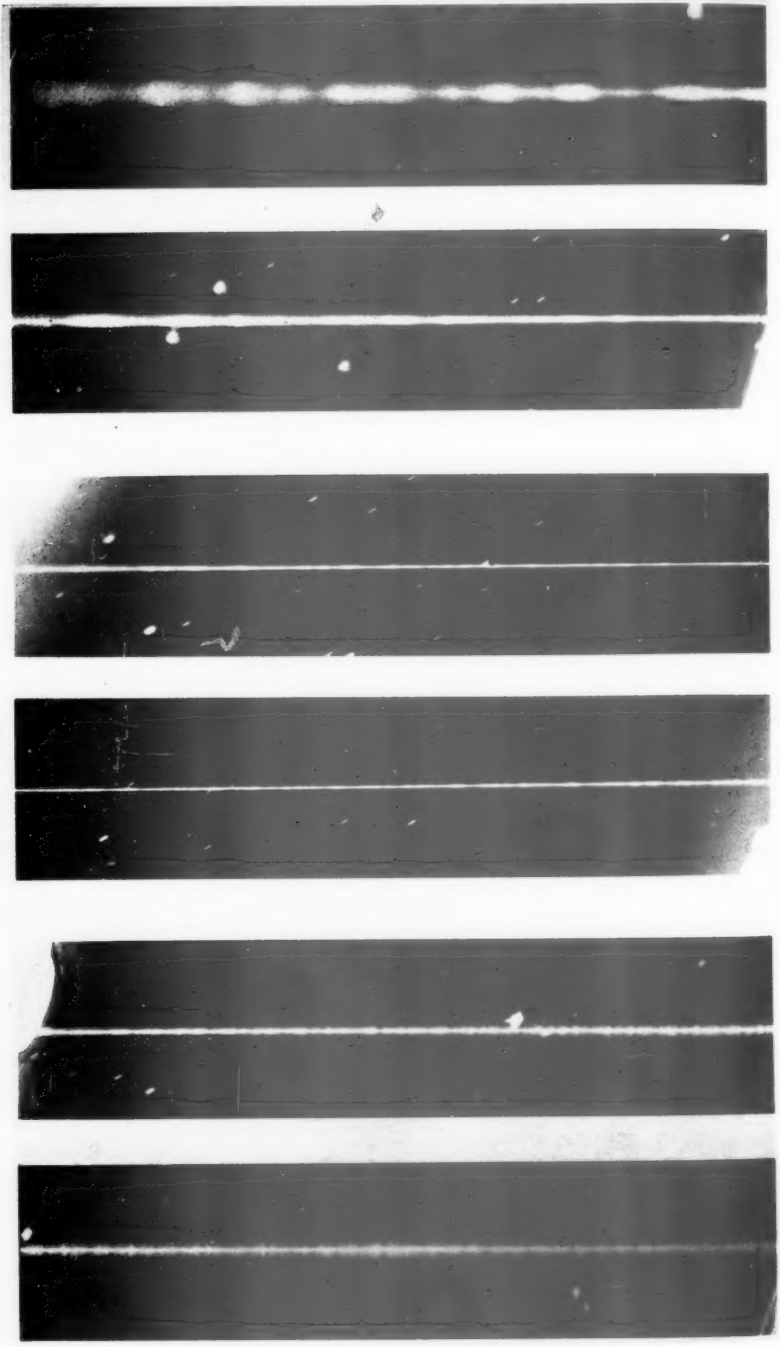

THE

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[THIRD SERIES.]

ART. XXIII.—*Fireball of January 13th, 1893.* By H. A. NEWTON. (With Plate III).

1. ON the evening of January 13th, 1893, Mr. John E. Lewis of Ansonia, Conn., was engaged in photographing the region of the heavens containing the place of Holmes's comet in hopes of securing a picture of the comet. The camera was strapped to the tube of his telescope, and inasmuch as his telescope was without a clock movement he kept the stars in place by giving by hand the proper right ascension motion to the telescope. The plate was exposed for thirty-three minutes, beginning at $7^h\ 19^m$ P. M. Mr. Lewis's eye was constantly at the eyepiece of the telescope, so that he was unaware of the passage of a bright meteor across the field of the camera until he developed the plate. The next morning he learned that the meteor, whose flight was thus accidentally photographed, had been seen to cross the sky about $7^h\ 30^m$ on the evening of the 13th. He announced in the newspapers that he had secured such a photograph and requested observations from those who had been so fortunate as to see its flight. Many responses came to Mr. Lewis and to me from various points in southern New England and southeastern New York. Mr. Lewis has kindly placed the photographic plate and all the letters received by him in my hands for examination and discussion.

2. The plate is 4 by 5 inches in size, and the meteor went nearly centrally across it. The photographed portion of the track was nearly 19° long. Near the center of the plate stars of the 10th magnitude are shown, while near the margin those

somewhat fainter than the eighth magnitude are in general visible. The disks in the latter case are much enlarged and are not entirely symmetrical. An enlarged reproduction of the track in several portions is given in Plate III.

3. Since we have thus a photographic picture of the meteor's path it seems worth while to put on record quite in detail the statements of the several observers from whom we have been able to secure reports. It should be borne in mind that such observations in the nature of the case have always to be made suddenly, and usually by persons not accustomed to exact observing. As a result the statements are always subject to large probable error, and quite large corrections have to be usually given to some or even to all of the observations if we would make them consistent with each other. The character of the observations is often shown in the language used in describing them. Hence original statements may properly be quite fully recorded.

4. *The meteor's path as seen from Boston, Mass.*—Miss Clara Binswanger of the Boston Public Library was walking on Columbus avenue (Lat. 42° 20′.5, Long. 71° 4′.9) and saw the meteor in the western heavens falling northward, rather obliquely. The color was a bright green, and it resembled an incandescent electric light in a green glass bulb. Mr. E. W. Abell, at my request, called upon Miss Binswanger and obtained more definite statements. He placed against the window a paper, and laying a ruler against it, asked Miss Binswanger to adjust the ruler to the slope of the meteor track as seen against the sky. Three trials were made, and the results sent to me gave inclinations of 37°, 35° and 27° respectively with the vertical. The meteor disappeared to her by passing behind the edge of a building. Miss B. indicated the height at disappearing as about $\frac{3}{4}$ of the height of the vertical edge of the building and described the place on the west side of Columbus avenue from which she saw it. Mr. Abell was able to determine very nearly the place where Miss Binswanger stood, and the building behind which the meteor disappeared. Her description indicates an altitude of about 7° when the meteor passed out of sight behind the building. The edge of the building was about 100 yards distant from her. Mr. Abell's tracing from a city map combined with the known directions of the streets implies that the direction was S. 67° W.

5. *As seen from Roslindale, Mass.* (Lat. 42° 17′, Long. 71° 9′).—Mr. Frederick L. Wolkins of Roslindale was sitting by his table in his dining room and saw the meteor cross the southwesterly sky, going downward and northward. Mr. Abell on the 27th of January saw Mr. Wolkins and obtained estimates of the inclination of the path as he remembered it.

From three independent trials he obtained lines inclined 58°, 63° and 68° with the vertical. The meteor disappeared behind a ridge of land about 400 feet from the house, "at an altitude of perhaps from 5 to 7 degrees." At first Mr. Wolkins thought the meteor fell near him in a swamp beyond the ridge. It had a distinctly bluish color, and moved rather slowly. He compared the size to that of a croquet ball, and did not notice a train.

6. *As seen from Hingham, Mass.* (Lat. 42° 10′, Long. 70° 50′).—Mr. Julian L. Noyes says that the apparent path was about along a line drawn from the Pleiades through where Jupiter was on that day. The time was $7^h\ 30^m$. "From its start it gradually increased in brightness, and then went suddenly out. Its brightest point was about 25° above the horizon. I turned my head just in time to miss the brightest point, and did not see it break, although it might have done so. Then I saw the remnant continue its course with a very faint, dull, red light to within 5° of the horizon and then go entirely out. When it disappeared it was about 5° south of the west point of my horizon. It took a straight course, except that perhaps at the very last it curved a little downward. It could not have made its appearance much above where Jupiter was at that time. From shadows on windows and other appearances I should say that the portions of the course before the brightest point and after it were equal." Jupiter was at the time about due S.W. at an altitude of 42°; the Pleiades were just east of the Meridian and about 18° from the zenith.

Mr. G. E. Kimball and his son also saw the meteor from Hingham "very near $7^h\ 30^m$ o'clock about $\frac{1}{3}$ of the way up the zenith at about due west." It appeared at first like a bright fixed star and suddenly seemed to drop from its place, moving toward the north with a brightening glow.

7. *As seen from Concord, Mass.* (Lat. 42° 29′, Long. 71° 22′).—Mr. Fred. A. Tower of the Massachusetts State Weather Service saw the meteor and gives the time as $7^h\ 40^m$, P. M. It was blue in color, and its brilliancy exceeded that of a first magnitude star. He gave the altitude as 70° at appearance, and 25° at disappearance. I requested Mr. Tower to look at the heavens at the proper hour and compare the path as he recollected it, with the constellations. He replied after such comparison, "I should say that it began in the constellation Taurus, and ended in the constellation Aquarius."

8. *As seen from Leominster, Mass.* (Lat. 42° 31′, Long. 71° 44′).—Mr. N. Harwood saw it at $7^h\ 30^m$. When first seen it was 40 to 45 degrees high in the S.W. It descended in a curve towards the north or northwest and disappeared from

view at an altitude of 20° to 25°. "When first seen it was small and dim,—when it disappeared it was brilliant, and apparently 4 to 5 inches in diameter. I did not notice it burst in pieces. It seemed to disappear almost instantly, leaving a small trail at the last." In his first letter to me Mr. Harwood gave the altitude when first seen as 25 to 35 degrees.

9. *As seen from West Medford, Mass.* (Lat. 42° 25′, Long. 71° 8′).—Mr. Geo. B. Frazar saw the meteor fall for a considerable distance, almost vertically, and go behind a barn 150 feet distant from him. It was very bright and intensely clearly defined. The direction was determined by a pocket compass to be between West and W.S.W.; perhaps nearer W.S.W than West.

10. *As seen from Berlin, Conn.* (Lat. 41° 38′, Long. 72° 46′).—Mr. J. E. Beale, editor of the Berlin Weekly News, as he was going out of his office had his attention suddenly aroused by the brilliant light. Judging by the time that elapsed before he got sight of the meteor he thinks it started northeast of the zenith, and the distance from its starting point to where it exploded must have been fully 90°. The course was about two points south of west and the time about 7^h 35^m. It burst without any noise, throwing out five or six globes of colored light similar to a sky rocket. The flight was apparently very slow.

11. *As seen from Branford, Conn.* (Lat. 41° 17′, Long. 72° 49′).—According to a notice in the newspapers Mr. G. W. Calkins about 7^h 30^m saw the meteor cross the sky from S.E. to N.W. Just over the town it exploded and broke into three pieces which probably fell into the Sound. No detonation was heard.

12. *As seen from New Haven* (Lat. 41° 18′, Long. 72° 55′).—Mr. S. W. Glenney saw it in the N.W. at 7^h 30^m by his watch. It had a beautiful blue color, and left a long trail of red which resembled sparks. He saw it explode but heard no report. The path had a slight curve with a direct downward course. When it exploded it seemed to him to be very near the earth.

13. *As seen from Stratford, Conn.* (Lat. 41° 12′, Long. 73° 8′).—Miss Alice E. Curtis says it was of a bright blue color and was going toward the N.W., too far to the west she thought for fragments to have fallen in Connecticut.

14. *As seen from Newtown, Conn.* (Lat. 41° 25′, Long. 73° 18′).—Mr. John J. Northrop was with a friend driving, and they saw the body just before it broke. It deseended in a northwesterly direction, more westerly than north, that is, in the direction of Poughkeepsie, or the Catskill Mountains. They thought that it fell beyond the borders of Connecticut.

15. *As seen from near Stevenson, Conn.* (Lat. 41° 22′, Long. 73° 13′).—Mr. G. W. Bradley was driving between Botsford and Zoar with a friend. They saw a flash, looked up and saw the meteor explode, and heard the noise. "In coming over the hills of Zoar it must have nearly touched the trees here." The time was 7^h 30^m and they were certain that when it exploded it was not over ¼ mile from them because they heard the report in a few seconds.

16. *As seen and heard from Danbury, Conn.* (Lat. 41° 23′.7, Long. 73° 28′).—Mr. Marcel Foubert observed a flash of light and looking upwards saw a meteor of unusual brilliancy. It left a long luminous trail behind it. When the meteor reached the vicinity of the Pleiades it exploded scattering bright red pieces in every direction. The report of the explosion was very slight, and the interval between the explosion and report was but a few (three or four) seconds. Its direction was northwest.

17. On the 6th of April I went to Danbury and saw Mr. C. R. Curtis, an intelligent farmer living two and a half miles N.W. of Danbury (Lat. 41° 25′.6, Long. 73° 29′). He was startled on that evening by the bright flash of light, looked up and saw the meteor overhead. It was perfectly stationary in the heavens. This want of apparent motion was a surprise to him. For a time it grew in brightness, and then diminished and went out without changing place. The color was at first white, but later was red. The duration of the phenomenon he thought was about 12 seconds. He indicated at my request the time, which by my watch was about 7 seconds.

18. *As seen from Bethel, Conn.* (Lat. 41° 22′, Long. 73° 25′).—According to the Danbury News Mr. Louis Ohlweiler, of Bethel, heard an explosion like the sound of a pistol shot, though not as loud, directly overhead. Looking in the direction of the explosion he saw five balls of fire spread out like the balls of an exploded rocket. To him the balls seemed about the size of an egg and blue-white in color, like electric lights. He kept the balls of fire in view for three seconds, when they vanished in darkness.

19. *As seen from Pawling, N. Y.* (Lat. 41° 38′, Long. 73° 36′).—Mr. J. Frank Smith saw it a little east of south, and its course seemed to be nearly vertical.

20. *As seen from near Poughquag, N. Y.* (Lat. 41° 43′, Long. 73° 41′).—Miss Statia C. Brill was driving with other persons. They saw it a little east of south. It seemed to fall somewhere near the mountains about West Pawling. The explosion was accompanied with about as much sound as a rocket would make, barely as much.

21. *As seen from Newburgh, N. Y.* (Lat. 41° 31′, Long. 74° 1′).—A gentleman while looking towards the east was attracted by a bright blue light. The roof of a house partly hid the display from him. At first glance it seemed to be nearly stationary and he was almost convinced that it was a piece of fireworks, but on looking again, the rapid shooting of the fiery body obliquely towards the north convinced him that it was a meteor, and the brightest he remembered ever seeing. He would say that it dropped directly east of Newburgh and either on or east of the Fishkill Mountains. Two other observers in Newburgh walking in South street, saw the meteor descend from a point in the east, and fall quite near the Groveville toboggan slide across the Hudson River. It was of a greenish tint, very brilliant, large and beautiful. Another person describes it as of a raspberry hue.

22. *As seen from Howell's Depot, N. Y.* (Lat. 41° 28′, Long. 74° 15′).—Mr. James N. Mapes says, that it was almost east of him.

23. *As seen from Nanuet, N. Y.* (Lat. 41° 5′, Long. 74° 0′). Mr. J. H. Stertzer was walking in a northeasterly direction when he saw the meteor. It began east of the zenith 65° to 70° high, and broke at a height of about 45° and N.E. of the zenith. It appeared to be about the size of a man's head, and its light was equal to that of the full moon. It lasted about one second.

24. *As seen from near Rosendale, N. Y.*—Mr. C. Veeder was driving (Lat. 41° 53′, Long. 74° 5′), and saw the meteor fall in an easterly direction.

25. *As seen from New York City.*—Mr. William H. Caldwell was in Central Park near the south end of the mall. The meteor appeared to have started a little east of the mall, and seemed to be very near the earth. It had a bluish color with a long tail and was at least five seconds in the sky. "After the tail had disappeared a red ball appeared to fall towards the earth for at least a second and fade slowly out of sight." He thought he heard a slight detonation like a skyrocket. A rough sketch accompanying his letter showed a course of the meteor toward the left, and making an angle less than 45° with the horizon. The mall is directed about N. 16° E.

Mr. Oliver B. Culley was walking along Third avenue between 129th and 130th streets when he saw the meteor. It described an angle with the horizon of about 40° to 45°, and broke into fragments of various sizes at the height of about 25° or 30° above the horizon, and about half way between E. and N.E., or rather more to the east. It had a brilliant blue color.

Mr. Henry Hartman saw it from Washington Heights "at an angle of about 45°," and its diameter before bursting seemed about 16 inches. It burst into fragments before disappearance.

26. *The Lewis Photograph.*—The track which appears on Mr. Lewis's photograph has very clearly marked margins, and part of the way has also a clearly defined central track. The stars near the center of the plate have well rounded figures, and even near the margins of the plate the star figures can be bisected with a fair degree of accuracy. The probable error of position is less evidently than that of the Bonn Durchmüsterung places. I therefore selected from the stars near the track six couples of stars, and one isolated star each of which had been observed at Leyden. The couplets were of stars near the track, one on each side of it. No second suitable star was available on the plate for use with the odd star. With a filar micrometer the distances of these stars from the track were measured and the position of the point where the line joining two stars of a set cut the center of the meteor track was computed. This process avoided the necessity of considering the scale value of the micrometer screw, except for the distance of the odd star from the track.

TABLE I, *showing the measured positions of seven points on the photographed meteor path, and their distances from a great circle through the extreme points.*

No. of point.	Name of star, B. D.	R. A. of star Leyden, 1875·0.	N. Decl. of star, Leyden, 1875·0.	Places of points in meteor path. R. A., 1875·0.	Places of points in meteor path. N. Decl. 1875·0.	D'viat'n from G.Circle
1	33°. 273	1h 33m 15s·12	33° 42′ 24″·4	1h 33m 15s 12	33° 48′ 20″·0	0″·0
2	33 . 234	1 20 0·26	33 43 39·5	1 20 0·15	33 47 57·0	−10·2
	33 . 233	1 20 0·05	33 52 14·6			
3	33 . 190	1 7 20·97	33 39 40·9	1 7 15·40	33 42 30·6	−23·3
	33 . 189	1 7 9·82	33 45 20 3			
4	33 . 138	0 50 44·79	33 29 38·7	0 49 58·38	33 27 24 7	−31·0
	33 . 133	0 49 14·70	33 25 18 8			
5	32 . 101	0 30 12·45	33 1 51·2	0 30 6·62	32 59 11·0	−15·0
	32 . 99	0 29 44·39	32 49 1·0			
6	32 . 85	0 25 44·39	32 45 42·7	0 25 12·20	32 50 7 7	−25·3
	32 . 80	0 24 47·58	32 53 30·4			
7	32 . 48	0 14 21·67	82 17 10·7	0 13 51·91	32 27 1 7	0·0
	32 . 42	0 13 10·82	32 40 37·5			

In this way were obtained the right ascensions and declinations of seven points on the track. In Table I are given the comparison stars with their places as determined at Leyden. In the fifth and sixth columns are the seven places centrally on the track. Drawing a great circle through the two extreme places and computing the declinations on that circle for the right ascensions of the fifth column, and subtracting these

from the declinations in the sixth column we have the remainders in the seventh column. These residues, taken strictly, imply that the meteor path was curved a little, the concavity being to the north. But if a great circle is drawn 15″ north of the one already computed as passing through the extreme points it will represent the seven places with extreme deviations of about 15″. This is not greater than the average errors of measurement from the plate as shown by the agreement *inter se* of individual measures. A very slight curvature of path is therefore indicated but is clearly not proven.

27. *Possible causes of curvature of path.*—The effect of gravity, and that of the rotation of the earth carrying the camera, to produce curvature of path would be in the opposite direction to, and for any reasonable supposition as to velocity would be much smaller than, that indicated by the residuals in column seven. If the meteor's light has the same refraction as that of the stars there would be from this cause a small theoretical curvature of path, since the starlight comes through the whole atmosphere and the meteor-light only through a part of it. But this cause too would furnish residuals very small compared to those of column seven, and they would be opposite in sign. If there is any curvature we may therefore refer it to glancing in the air caused by the atmosphere's resistance of the irregularly shaped body.

28. *Time at which the meteor appeared.*—A number of the observers say that $7^h\ 30^m$ was the actual or approximate time of the appearance of the body. These were Mr. Noyes and Mr. Kimball at Hingham, Mr. Harwood at Leominster, Mr. Calkins at Branford, Mr. Glenny at New Haven, Mr. Bradley at Stevenson. Mr. Beale at Berlin says 7.35. Mr. Curtis of Danbury placed it later than 7.30. Mr. Tower at Concord says $7^h\ 40^m$. As the time of the 75th meridian from Greenwich is in use in the whole region there is no correction for differences of local time. No one names a time earlier than $7^h\ 30^m$. Probably there is a slight tendency to name a time which is too late, since the ordinary observer of such a meteor does not at once note the time, being interested in the appearance of the body. Hence it is safe to take $7^h\ 30^m$ as not far from the true time of appearance. It may easily have been however two or three minutes later.

29. Mr. Lewis's latitude in Ansonia was 41° 20′ 40″, and his W. longitude 73° 4′ 20″. Allowing for precession, etc., I find that the plane that passed through Ansonia and the path among the stars as photographed by him cut the earth at $7^h\ 30^m$ in a line which crosses the meridian of 73° 28′ (that of Danbury) at latitude 41° 25′ 9″. Each minute of time later than $7^h\ 30^m$ would carry that point of intersection with the meridian of

Danbury north 3″·6 or about 370 feet. The line for $7^h\ 30^m$ crosses centrally the upper Kohanza reservoir as given upon the Danbury sheet of the new map of Connecticut. The plane was at $7^h\ 33^m$ inclined 10° 3′ to the vertical at Ansonia, and the earth's rotation in five minutes would change this inclination by a very small quantity, a quantity, however, so small that it may be safely neglected.

30. The various observations reported in 4–25 when used for computing the meteor's path through the air are of necessity liable to large errors. This is almost universally true for such meteors. The proper adjustment of the unavoidable discrepancies is a matter of some delicacy. No systematic treatment like the method of least squares is feasible. No formal system of balancing the errors, or taking an average seems proper. The difficulties that arise are not those which a mere computer meets with, but are much more like those which a judge encounters when the witnesses give conflicting stories. The judge hears the evidence of all the parties, and then taking into account the way in which witnesses are accustomed to use language, and all the necessary and all the probable relations of the parties and things concerned, works out of conflicting stories what to his mind is the most reasonable statement of the facts.

31. If a meteor's path through the air is regarded as part of a straight line the location of that line is evidently determined by four conditions; or, if the beginning and ending of the body's path are to be found, two more conditions, six in all, are to be fulfilled. Each usable observation taken by itself gives one or more equations and reduces by one, or more than one, the number of remaining conditions. When, however, the observations furnish more equations of condition than the four or six required an adjustment becomes necessary.

In practice I have found it better in collating meteor observations to first select the best observations and use these exactly as made to reduce the number of unknowns to be found. In the present case the photographed track is of course the best observation, and it furnishes two out of the four conditions needed to fix the line of the meteor's motion. The photograph determines a plane through Ansonia and the required line. Relative to the stars the plane is quite exactly determined, the errors being principally such as are caused by errors of the measurements which I made on Mr. Lewis's original slide. The probable error of one measurement I estimated at about three-tenths of a minute of arc. The relation of this plane to the earth's surface, and so to other observers is however further affected as shown above (29) by the uncer-

tainty of the epoch of the flight, since the earth was rotating relative to the plane passing through Ansonia and the track.

32. Next to the photograph the statements of Mr. Curtis (17) combined with the several statements in 18–25 seem least fitted for fixing one point in the line of the meteor's motion. Mr. Curtis was probably a few hundred feet north of the photographed plane, but he could not have been far from it because by reason of the earth's rotation that plane passed over Mr. Curtis's place between $7^h\ 30^m$ and $7^h\ 35^m$. To Mr. Curtis the meteor seemed perfectly stationary. This was probably not strictly true. We can only assume that the apparent motion was to him *not very large*. The body was moving at an inclination to the vertical, as will be seen, of 40° or 50°, and when it disappeared was not many miles from him. If the real path continued met the ground much to the east of him, the apparent path seen by Mr. Curtis would have gone down towards the horizon to the east-southeast; if much to the west of him the apparent path would have gone upward nearly vertically, but a little to the south, toward a point south of the zenith. I believe, if the meteor had been directed to a point more than two or three miles either east or west of Mr. Curtis, that he would in the seven seconds, more or less, during which he was watching it have noticed the downward or upward motion of the fireball. I shall assume therefore that the line of the meteor's path met the ground in Lat. 41° 25′·5, Long. 73° 29′. This point I shall call Clapboard Ridge.

33. The reports from N. Y. State, are in accord with and confirm in a general way this assumption.

Mr. Smith (19) sixteen miles N. 23° W. from Clapboard Ridge says that it fell a little east of south.

Miss Brill (20) twenty-three miles N. 28° W. from Clapboard Ridge says it fell a little east of south.

To observers in Newburgh (21) twenty-nine miles N. 77° W. it fell in the east.

Mr. Mapes (22) forty miles N. 86° W. saw it almost east of him.

Mr. Stertzer (23) thirty-six miles S. 49° W. says that it broke N.E. of the zenith at a height of 45°. Altitudes in such cases as this are usually overestimated. This observation together with those reported from Rosendale and New York City (24 and 25) so far as they are definite are all fairly well represented by the assumption made.

34. We have thus established three out of the four conditions which the straight-line path of the meteor must satisfy, namely, the line must pass through Clapboard Ridge, and must lie in a plane passing through Clapboard Ridge and Ansonia, which plane is inclined to the vertical of either Clap-

board Ridge or Ansonia a little more than ten degrees. (The elevations of Ansonia and Clapboard Ridge above the sea may in this case be neglected.) The remaining condition is less exactly determined by the observations. The best unknown to use is the place of the meteor's quit, that is, the point on the celestial sphere from which the meteor was moving.

35. A glance at the observations in and near Boston, and in N. Y., shows that the meteor was moving in that plane at a large angle with the vertical and also at a large angle with the horizon. But no one of the observations has by reason of the position of the observer, or other quality, a clear right to be used to the exclusion of the others.

36. The meteor's path is assumed to be a right line; hence its apparent path to each observer must be an arc of a great circle on the heavens. The true path produced passes through Clapboard Ridge; the circle of its apparent path must contain the point near the horizon in which Clapboard Ridge would be seen by the observer. The apparent path produced backward on the sky must contain the meteor's quit We must determine on the photographed arc a place for the quit such that the various observations shall be best satisfied, regard being had to every known quality of the observations.

37. An artificial globe (celestial or terrestrial) is convenient for the study of the problem. Set the pole of the globe in the zenith, and then the meridians are vertical circles. If the statements of the observers are not definite enough (and they are not in this instance) to make it worth while to consider the different places of the zeniths of the observers, we may treat the pole of the artificial globe as the zenith of each observer. Then, the point on the horizon in the azimuth of Clapboard Ridge from the observer must be in the circle of each observed path. Assume on the photographed path a quit, and suppose arcs drawn from this quit to the several horizon points. If the quit is correct the observed paths were in these arcs. Move the quit up or down the photographed circle until the arcs represent the statements of the several observers with the least violence to the language used. Instead of a globe a stereographic or a central projection of a hemisphere may be used. If the observations warranted greater refinement of treatment methods of computing could be easily devised. I find that if the quit is taken 45° from the line joining Clapboard Ridge to Ansonia the various accounts will be satisfied about as well as if the quit was assumed to be at any other point in the photographed plane.

38. The distance from Ansonia to Clapboard Ridge is twenty-two miles and I assumed that the angle at Clapboard Ridge is 45°. The length of the track on the photograph

plate was 18°·8. The place where it entered upon the plate was 72° 7 from the horizon measured in the photographed plane. These data show that at the entrance of the fireball upon the photograph plate it was 17·6 miles from the camera, and at the other margin of the plate it was 15·75 miles distant. The length of the photographed track was five and three-fourths miles. The altitudes above the earth were 16·5 and 12·5 miles respectively. According to the usual hypothesis of the density of the air as we ascend, the barometric pressure at the middle of the photographed track was a little less than two inches, and the pressure was more than twice as much at the lower as at the upper point. The uncertainty in the numbers in this article is not very great. The principal cause of uncertainty is the want of exactness in the location of the quit, and the triangles are so located that this cause cannot largely affect numbers given. The residuals not exceeding 15″ in (26) that indicate possible curvature correspond to deviations of the path from a plane not exceeding 6 feet.

39. In Plate III is given an enlarged print of the photographed track in six portions. It is about twenty six inches long, so that it represents in length the track on a scale of 1 : 14000. The breadth of the track in the photograph at the two ends is due to want of exact focus. Owing to changes during the processes of reproduction the print shows the path near its end much narrower than did the original plate. On Mr. Lewis's plate the path shows near the end a clearly marked central line and a smoothly limited marginal region five or six minutes in breadth. The latter is only faintly reproduced in the plate.

40. The stone was evidently single during its passage across the field of view. The breaking up which was noticed by several observers took place lower down.

The irregularities of light in the path increase notably in frequency towards the end of the plate. At first they recur only after hundreds of feet, while near the end they are perhaps ten times as frequent. Such irregularities might be due to small fragments breaking off from the main mass. But it would seem reasonable that in that case we should be able to detect small spurs of light from the path and of these I see no trace. It seems much more reasonable to suppose that the stony mass was in rotation, more rapid at the end than at the beginning, and that unequal amounts of burned material were thrown off according as a well burned or a raw surface was for the instant in front.

Art. XXIV.—*On a Photometric Method which is independent of Color;* by Ogden N. Rood.

The principle underlying most of the photometric methods now in use depends on a comparison of the illumination of two adjacent fields; in some instances as where a spot or a ring is made to disappear, this idea is thinly disguised, but instantly becomes apparent when the lights are differently colored.

The object of the present paper is to present a mode of procedure in which the coloration of the two surfaces, even though at a maximum of vividness, is a matter of entire indifference, since the process depends not on a comparison of these surfaces, but on the shock which the retina experiences when one surface is quickly withdrawn and replaced by another. If we take a uniform circular disc of any color, illuminate it evenly, and then set it in rotation slowly or rapidly, the retina will receive no shock, since the parts replacing each other in the retinal image are in all respects identical, in other words no flickering will be perceived. If, however, one-half of the disc reflects less light than the other by $\frac{1}{50}$ of the total amount, with appropriate rates of rotation a faint flickering will be noticed, which will increase in intensity as the difference of the luminosities of the two halves of the disc is made greater.

Accordingly I prepared a set of about a hundred discs of drawing paper, their depth of tint ranging from the whitest white paper down to the blackest, the gradation being as even as practical. For the determination then of the reflecting power, for example of a vermilion disc, it was only necessary to select from the series a gray disc which when combined with it in equal parts gave no perceptible flicker, and afterwards to determine the reflecting power of this gray disc in terms of the standard white cardboard. Results were thus obtained for the principal colors, red and blue-green, yellow and blue, green and purple. The difficulty in measuring the reflecting power of these colored discs was in all cases the same, and was due to the fact that it is hard to obtain gray discs with absolutely uniform surfaces. This trouble, or a lack of uniformity in the colored discs themselves, was to a considerable extent obviated by reversing the halves of the composite disc so as to employ the previously unused surfaces. Small irregularities, texture, or a sandy appearance do not interfere with the use of the discs to a noticeable extent, but when the depth of the tint changes slowly over an extended surface it gives more trouble. Of course the case frequently arose where in the entire hundred discs not one could be found with

which the flickering entirely disappeared with quite low rates of rotation, and here it was necessary to determine with which gray disc the flicker was at a minimum. This was accomplished by combining the same colored disc with *two* gray discs, a larger and a smaller, on the same axis, when it would become evident which was the more favorable combination, and the observer would notice that the luminosity of the colored disc must be nearer to one gray disc than to its mate, or about equally distant from both.

As before stated results were obtained for six discs, but these were selected so as to be complementary to each other in pairs, and in order to test the process they were now combined pair-wise and the resultant luminosities of their gray mixtures were determined by the old method, and afterwards *calculated* on the basis of the figures furnished by the flickering process.

	Gray mixture.	Diff.		Gray mixture.	Diff.
Purple and green	27·5 observed 27·5 calculated	0	Red and blue-green	20·2 observed 21·1 calculated	$\frac{9}{10}$

	Gray mixture.	Diff.
Yellow and blue	27·85 observed 29·1 calculated	1·25

These experiments were not at all elaborate, and as their greatest difference barely exceeds one per cent of the reflecting power of white cardboard, they may be taken as furnishing a proof of the correctness of the process employed.

Thus far we have dealt with the combination of white (gray) discs with those that are strongly colored, and it remains to give an example of the process as applied to two differently colored but not complementary discs. To test this matter it was necessary to find two colored discs having the same or nearly the same reflecting power. In my collection I finally found two such discs, a cyan-blue with a reflecting power of 23·9 and a purple for which the figure 23·3 had been obtained: these discs when combined gave a scarcely perceptible flicker. Since then, graded series of yellow discs have been made, but it has been impossible to find time to hunt up their equivalents in luminosity and make the necessary determinations.

This flickering process having answered so well, the procedure was reversed, and used with great advantage to facilitate the determinations of the values of the gray discs executed in the ordinary way; in other words the series of gray discs as made by myself is not pure gray but has a slightly yellowish tint that makes estimation on equality of luminosity a little more difficult than it ought to be. Accordingly in measuring

the reflecting power of the gray discs by the old method, the standard white and blacks discs were combined with a *small* amount of an orange-yellow disc which made their mixture match the tint of the gray disc under experiment. The luminosity of the orange-yellow disc in terms of standard white card-board being known, the final result was calculated with equal facility and the annoyance removed. It is hardly necessary to add that in all cases the amount of white light reflected from the standard black disc was taken into account.

An experiment was now made to test the flicker process by using it to determine the reflecting power of two gray discs which were afterwards measured in the ordinary way, and the following result was obtained:

Direct determination.....	34·1	29·1
Flicker "	33·7	28·6
Difference	·4	·5

These determinations were not elaborate but may suffice for the purpose.

Afterwards a more careful set of observations was made to ascertain with what minimum difference in luminosity the flicker became insensible; a series of five light-gray discs was made with gradations so small that these would have required elaborate work for their individual determination which was not attempted, directly, the method of measuring the least and the most luminous disc being employed, and the difference between the figures divided by four. When these discs were tested flicker fashion in pairs, it was found that the intervals between them were not at all identical, one being larger and its neighbor smaller than the average interval, but each pair nevertheless furnished a faint but distinct flicker. If the intervals had been regular, as was intended, the experiments would have proved that with a difference of $\frac{1}{50}$ part of the total light a flicker could be perceived; as it was, it showed that a considerably smaller difference suffices, probably about $\frac{1}{100}$.

It is evident that for the purpose of measuring the reflecting power of colored discs, it will not in every case be necessary to undergo the labor of making an elaborate set of gray discs; if the experimenter is furnished with six or eight brilliantly colored discs, the reflecting power of which has been carefully determined, then, with these and black and white discs, he will be able to match new discs and measure their luminosity in the old way.

There does not seem to be any reason why this process with the aid of well known optical devices should not be applied to ordinary photometric work, or to such as is carried on in the interior of the observing telescope of a spectroscope. In simple work with discs like that here presented, the flicker photometer is necessarily on the model of a stair case, and the transitions though small are always abrupt; but when there are other modes of regulating the illumination this would not be the case, and the advantage of multiplying observations would be more fully experienced. Some experiments for dividing up even the interval between two discs have been begun, with promising results, but are not yet finished.

It is well known that gazing steadily at a flickering surface is trying to the eyes, but in the operations above described no inconvenience whatever from this source was experienced, since if the flicker was strong a glance revealed the fact and another disc was substituted; the faint flickering which demands more prolonged attention seems to be no more trying to the eyes than ordinary optical work.

It may be a matter of some interest in physiological optics to know that the sensation called "flickering," is independent of wave-length and connected with change in luminosity. When two differently colored surfaces of the same luminosity are successively presented to the eye as above described, no shock is experienced, and the colors are seen to mingle in a soft streaky way; if observation is prolonged for some time, subjective effects begin to manifest themselves especially with quite low rates of rotation; it is of course best not to study these with undue curiosity.

Columbia College, June 19th, 1893.

ART. XXV.—*Actinolite Magnetite Schists from the Mesabé Iron Range, in Northeastern Minnesota;* by W. S. BAYLEY.

ATTENTION has been repeatedly called to the existence of beds of amphibole schists associated with the ores in the older iron regions of the Lake Superior District. Brooks,* Wichmann† and Wright‡ referred to those occurring in Wisconsin under the name actinolite schists and anthophyllo-actinolite schists, and Julien‖ under the name tremolite-schists. Those

* T. B. Brooks: Geol. of Wisconsin, vol. iii, 1873–79, p. 525, 577, 578, etc.
† A. Wichmann: Ib., vol. iii, p. 639, etc.
‡ C. E. Wright: Ib., vol. iii, p. 699, etc.
‖ A. A. Julien: Ib., vol. iii, p. 226, etc.

found in Michigan have been called anthophyllite-schists by Brooks and Brush* and by Julien.† In the Penokee district of Michigan and Wisconsin, Irving and Van Hise‡ describe them as actinolitic and magnetitic slates, and mention them as forming a portion of the iron-bearing member, just below the upper fragmental slates and immediately above the similarly fragmental vitreous quartzites of the Penokee series. They are associated with slaty and cherty iron carbonates and with ferruginous slates and cherts, regarded as chemical sediments.

Lane and Sharpless§ have recently shown that in some of these schists from the Marquette area the amphibole is rich in iron and magnesium, while entirely devoid of even a trace of calcium, and hence that it should be classed with the variety grünerite.

The relations of these schists to the other members of the iron-bearing series have been made out only in the Penokee area as above stated, though they are said by Irving and Van Hise‖ to be intimately associated with cherty carbonates in the Animikie rocks of Minnesota.

The widespread occurrence of these peculiar rocks throughout all of the iron-bearing horizons of the Lake Superior region that have been subjected to more than a merely superficial examination, must be of significance. Consequently the discovery of them on the newly opened Mesabé Range¶ is of some interest from a theoretical, if not from a practical standpoint. The object of this note is simply to announce this discovery and to describe very briefly the characteristics of the rocks.

The easternmost end of the Mesabé area is in the vicinity of T. 61 N. R. 12 W. Minnesota. In the S.E. ¼ of the S.E. ¼ of Sec. 34 in this town, and only half a mile from the north side of the great gabbro mass lying to the south, is a series of dark, heavy schists highly charged with magnetite. Of these eight specimens have been examined, the geological associates of which are unfortunately not known. Under the microscope it is seen that these rocks consist almost exclusively of magnetite and an almost colorless amphibole.

The magnetite forms from fifty to ninety per cent of the entire rock-mass. It occurs as large and small grains imbedded

* T. B. Brooks and G. J. Brush: Geological Survey of Michigan, vol. i, 1869–1873, p. 114.

† A. A. Julien: Ib., vol. ii, 1873. p. 24, 91–93, etc.

‡ R. D. Irving and C. R. Van Hise: The Penokee Iron-bearing Series of Michigan and Wisconsin, 10th An. Rep. U. S. Geol. Survey, p. 389.

§ A. C. Lane and F. F. Sharpless: this Journal, xlii, p. 505, 1891.

‖ R. D. Irving and C. R. Van Hise, l. c., p. 404.

¶ H. V. Winchell: The Mesabé Iron Range, Geol. and Nat. Hist. Survey of Minn., 20th Ann. Rep., p. 111.

in the amphibole. The smaller grains, with the exception of the tiny dust particles scattered through the amphibole, all show traces of octahedral or cubic faces. The larger grains are very irregular in outline, but their irregularity is due rather to the agglutination of tiny grains with crystallographic contours than to the accumulation of masses with accidental boundaries. Traces of octahedral faces may be seen in nearly all of the large magnetite masses, and in some cases these latter appear to be sections of well developed crystals.

The amphibole is in large colorless plates that interlock by irregular sutures, or in sheaf-like bundles of tiny fibers. In the former case the mineral includes magnetite so thickly that in the hand-specimen the rock appears finely granular; but it reflects light evenly from large areas, and these upon close inspection are learned to be the cleavage faces of the amphibole. In cross section the plates sometimes present well marked crystallographic outlines in which the prismatic planes of hornblende are plainly distinguishable, and these sections are crossed by two cleavages cutting each other at the hornblende angle of 124°. In other sections only a single cleavage is apparent as a series of parallel lines against which the extinction is about 14°. The double refraction of the mineral is fairly strong and is negative, and the plane of its optical axes is parallel to the single cleavage. In two of the sections studied many of the plates are crossed by polysynthetic twinning lamellæ as in the case of the grünerite described by Lane and Sharpless.

The fibers in the sheaf-like bundles are colorless like the material of the plates or are very light green. Their extinction is sometimes parallel to their long axes and sometimes is slightly inclined to them. Their double refraction is somewhat stronger than that of the plates and their polarization colors are usually very brilliant. Their axes of least elasticity are nearly parallel to the longitudinal directions of the needles which are therefore negative, if the orientation of their optical axes is as it is in normal hornblende. Two cleavages are discernible, one parallel to the long directions of the fibers and one (a parting) transverse to them. Cross sections of the bundles were not seen.

The properties of the plates and of the fibers sufficiently characterize both as a tremolitic or actinolitic hornblende or as grünerite.

A second amphibole intergrown with the colorless variety differs from this latter only in having a greenish tinge. It may also be slightly more strongly doubly refracting, but otherwise it is similar in all respects to the colorless mineral.

An analysis of one of the best examples of these schists, No. 8779, from S.E. ¼ of S.E. ¼, Sec. 34, T. 61, N. R. 12 W., Minn., yielded Mr. W. H. Melville the following figures:

	No. 8779.	No. 8784.
SiO_2	12·35	1·16
TiO_2	·12	none
Al_2O_3	·10	1·81
Fe_2O_3	58·68	69·08
FeO	21·34	27·10
MnO	1·22	·33
CaO	1·91	·53
MgO	4·08	·25
Na_2O	tr.	
P_2O_5	·25	·06
Loss	·19	
Total	100·24	100·32

This is a rock composed exclusively of large plates of the colorless amphibole and large grains of magnetite. The latter mineral was not analyzed, but a rock from near No. 8779, consisting of almost pure magnetite was analyzed by Mr. Melville, who reports the results entered under No. 8784. Neither the magnetite in 8779 nor that in 8784 contains any notable quantity of titanium, and thus they differ markedly from the gabbro magnetites bordering much of the south side of the Mesabé range.

With respect to the amphibole in this rock it is manifestly impossible to decide positively whether it is grünerite or actinolite. If we regard the Fe_2O_3 as existing in the magnetite, and ascribe to this component also the MnO, half of the MgO and sufficient FeO to satisfy the formula Fe_3O_4, there remain the other oxides, after deducting enough CaO to combine with the P_2O_5 in apatite, in the following proportions:

SiO_2	Fe_2O_3	Al_2O_3	FeO	CaO	MgO	Total
71·63	·92	·58	5·80	9·40	11·60	= 99·93

which are nearer those of actinolite than of any other amphibole, although the percentage of SiO_2 is abnormally large.

One specimen, No. 8783, consists of several alternating light and dark bands. Of the latter it need only be said that their composition is similar to that of the actinolite magnetite schists, i. e. they are composed of large plates of amphibole thickly strewn with grains of magnetite. The dark bands pass gradually into the light ones, the magnetite decreasing in quantity as the borders of the light bands are reached, until in the interiors of these bands all of this mineral has disappeared.

The principal components of the light bands are actinolite of the platy form, grains of a light green amphibole that may be a more ferriferous actinolite, and a few ragged grains of plagioclase. None of these constituents have sharp outlines. They all dovetail into one another even more irregularly than do the minerals of a granitic rock. In the little interstices that sometimes occur between the larger individuals and included within these in considerable quantity are many small and more or less rounded grains of a colorless mineral, whose isotropic sections show the straight bar of a uniaxial interference figure. Other sections are rhomboidal in shape. These are doubly refracting and they extinguish parallel to the diagonals of the rhomboids. The general aspects of the mineral, and its properties, so far as they can be determined, are those of quartz.

The descriptions above given agree very closely with those given by Irving and Van Hise* for the corresponding schists in the Penokee series, except that in the Minnesota rocks quartz is rare and hematite is absent. The presence of these peculiar rocks in the Mesabé range is noteworthy, since their origin in certain other districts is supposed to be very closely connected with the origin of the iron ores with which they are associated. If in the Mesabé district they are found to be related genetically with an original carbonate of iron, an important analogical link between the Mesabé and the Penokee series will have been established.

Art. XXVI.—*On some Double Salts of Lead Tetrachloride;* by H. L. Wells.

The existence of lead tetrachloride has long been surmised from the fact that the corresponding oxide, when dissolved in cold hydrochloric acid, gives a yellow solution in which sulphuric acid does not give an immediate precipitate. Lead tetrachloride itself, however, has never been isolated, nor has any double salt which it forms been satisfactorily described.

Sobrero and Selmi† found that when chlorine is passed into a solution containing sodium chloride and lead chloride, the liquid becomes yellow. They found it impossible to isolate the compound either by evaporation or cooling, so that they determined the lead, sodium and chlorine in such a solution, and found it to contain these constituents in the ratio corresponding to $PbCl_4+9NaCl$. Sobrero and Selmi say that per-

* R. D. Irving and C. R. Van Hise: l. c., p. 389–393.
† Ann. Chim. Phys., III, xxix, 161.

haps this is the formula of the compound, but they put a question-mark after it. Their analysis indicates the existence of $PbCl_4$ in combination with NaCl, but if the solution had contained a compound of that composition, which was stable with water, it probably could have been isolated by evaporation. The fact is that the double salts of lead tetrachloride are not stable with water, as will be shown in the present article. Therefore, since a large excess of sodium chloride must have been present in the solution of Sobrero and Selmi, their analysis could not have determined the composition of the double salt that it contained.

Nicklès* saturated a strong solution of calcium chloride with lead chloride and chlorine and analyzed the *solution*. He found it to contain lead, calcium and chlorine in the proportions represented by $PbCl_4+16CaCl_2$. In conclusion Nicklès does not claim that any such double salt exists, but merely claims to have indicated the existence of $PbCl_4$.

In view of the fact that the formulæ $PbCl_4+9NaCl$ and $PbCl_4+16CaCl_2$ merely represented the composition of solutions, it is remarkable that they are given in some handbooks of chemistry as real chemical compounds. It may be mentioned that Carnegie† has used the formula $PbCl_4.9NaCl$ in support of a theory on double halides.

O. Seidel‡ mentions unsuccessful attempts to isolate $PbCl_4$ and its double salts with the chlorides of other metals.

Fisher§ dissolved lead peroxide in hydrochloric acid and found that all the lead in the solution was precipitated again as peroxide by the addition of sodium acetate. He was evidently not aware of the fact that Rivot, Beudant and Daguin‖ had shown, long before, that lead is completely precipitated as peroxide by the addition of sodium acetate and chlorine to its solutions. Fisher found that two atoms of chlorine were used (as would be expected) in precipitating one atom of lead as peroxide. His conclusion that his experiments showed the existence of lead tetrachloride has, apparently, little foundation.

More recently, Ditte¶ has made some experiments on the solubility of lead chloride in solutions containing hydrochloric acid and chlorine. He apparently does not believe in the existence of lead tetrachloride, for he does not mention the compound, while he explains the precipitation of lead peroxide, when such solutions are diluted, by saying that lead chloride is partly dissociated by the act of solution, that the solution then contains oxide of lead, and that this is peroxidized by the

* Ann. Chim. Phys., IV, x, 323.
‡ Jour. pr. Ch., II, xx, 2e5, 1879
‖ Ann. Mines, V, iv, 239, 1853.
† Am. Chem. Jour., xv, 10. 1893.
§ Jour. Chem. Soc., xxxv, 282, 1879.
¶ Ann. Chim. Phys., V, xxii, 566, 1881.

oxides of chlorine formed when chlorine is passed into the solution.

Nikolukine has succeeded in isolating double salts of lead tetrachloride with ammonium and potassium chlorides. He showed that these compounds contain lead and extra chlorine in the proportion required for $PbCl_4$, but there is no evidence in the abstracts of his article* that he determined the composition of the double salts. His original article in Russian is not accessible to me. Nikolukine prepared the compounds by dissolving lead dioxide in concentrated hydrochloric acid in sealed tubes, and adding the alkaline chlorides to the solutions thus produced. He describes the double salts as having a lemon-yellow color, and states that they are pretty stable, the ammonium chloride compound being decomposed at 120°.

The present investigation has been undertaken with the view of determining the composition of the salts which Nikolukine discovered, and especially in order to investigate the corresponding rubidium and cæsium compounds, which, from analogy, were expected to be more insoluble and stable than the potassium salt. As a result, it has been found possible to prepare the whole series in a state of purity, and the expectations in regard to the easy preparation of the rubidium and cæsium salts have been fully realized. The following salts are to be described:

$$(NH_4)_2PbCl_6$$
$$K_2PbCl_6$$
$$Rb_2PbCl_6$$
$$Cs_2PbCl_6$$

These salts are all yellow, and they all crystallize in the isometric system with an octahedral habit.

These salts show a new relation between lead and other metals of Mendeléeff's group IV, with which this type is very common, especially among the double fluorides. It is to be noticed also that this type is almost invariable among the double salts which tetrahalides form, for platinum, iridium, osmium and palladium give analogous, isomorphous compounds, while, as has been recently shown by Dr. H. L. Wheeler of this laboratory, tellurium gives an extensive series of octahedral salts of this type. The octahedral form of the anhydrous salts of this type is very characteristic, and it seems to be universal, except among the fluorides.

All of the lead salts to be described are decomposed by water with the formation of lead peroxide. Chlorine is usually set free at the same time. It may be assumed that two successive reactions take place, which may be represented by the following equations:

* Berichte, xviii, 370, 1885; Jour. Chem. Soc., l, 123.

$$(1)\ PbCl_4 + 2H_2O = PbO_2 + 4HCl$$
$$(2)\ PbO_2 + 4HCl = PbCl_2 + Cl_2 + 2H_2O$$

The extent to which the second reaction takes place depends upon the dilution and the temperature. If the amount of water present is not too great, a state of equilibrium is reached when a sufficient amount of alkaline chloride, hydrochloric acid and chlorine have gone into solution, and the decomposition stops. The cæsium salt is more slowly decomposed by water than others. All the salts are decomposed by boiling with an excess of hydrochloric acid, but the decomposition of the cæsium compound is remarkably slow, especially in solutions containing much cæsium chloride.

When free chlorine is present the cæsium salt is almost completely insoluble in strong solutions of cæsium chloride and in hydrochloric acid. Although the rubidium salt is considerably more soluble, the difference is not great enough so that a quantitative separation can be made. It will be shown in the following article that cæsium can be approximately separated from potassium, sodium and lithium by this means, and that when rubidium is also present the cæsium can be approximately determined indirectly.

The salts to be described can be washed with hydrochloric acid containing chlorine. They are perfectly stable on exposure to the air. When heated in capillary tubes the ammonium salt begins to whiten at about 225°, the potassium salt at about 190° and the cæsium and rubidium salts at about 280°. This temperature for the decomposition of the ammonium salt is about 100° higher than that given by Nikolukine. It is probable that difference is due to a typographical error.

Attempts were made to prepare corresponding sodium and calcium salts, without success.

In analyzing the salts, lead was separated and weighed as sulphate, and, in the filtrate from this, the alkali-metal was determined as sulphate. To determine chlorine, a separate portion was decomposed by a solution of sodium arsenite and chlorine was determined in this as usual.

Ammonium-Plumbic Chloride, $(NH_4)_2PbCl_6$:—In preparing this salt, Nikolukine's method of using sealed tubes was found to be unnecessary. A solution of lead tetrachloride was made by adding slightly diluted hydrochloric acid to an excess of lead dioxide at 0°. This solution was quickly filtered through asbestus, and a saturated, cold solution of ammonium chloride in dilute hydrochloric acid was added until an abundant, yellow, crystalline precipitate was produced. The salt was pressed on paper, and then air-dried.

	Found.	Calculated for $(NH_4)_2PbCl_6$.
Ammonium	....	7·90
Lead	44·61	45·39
Chlorine	46·53	45·71

Potassium-Plumbic Chloride, K_2PbCl_6:—Chlorine was passed into a solution saturated with potassium chloride, lead chloride and hydrochloric acid at 0°, without producing the double salt. Nikolukine has stated that the salt is soluble in an excess of potassium chloride, and, acting upon this suggestion, another solution was made, like the former except that no potassium chloride was used. On mixing about equal volumes of the two solutions and letting the mixture stand at 0° for several hours, a well crystallized crop of the yellow double-salt was obtained. The air-dry salt was analyzed.

	Found.	Calculated for K_2PbCl_6.
Potassium	15·30	15·70
Lead	41·91	41·55
Chlorine	42·49	42·75
	99·70	100·00
Loss on heating	15·07	Cl_2 14·25

The above method of preparation gives a small yield, and it would probably be better to use a method analogous to that by which the ammonium salt was prepared.

Rubidium-Plumbic Chloride, Rb_2PbCl_6:—When 65^g of rubidium chloride were dissolved in 250^{cc} of water with 4^g of lead chloride, no precipitate was produced by saturating the solution with chlorine, but, on adding an equal volume of concentrated hydrochloric acid to this solution, an abundant, yellow, crystalline precipitate was produced. This was collected on a filter, washed with hydrochloric acid containing chlorine and air-dried.

	Found.	Calculated for Rb_2PbCl_6.
Rubidium	28·62	28·93
Lead	34·98	35·03
Chlorine	35·85	36·03
	99·45	100·00
Loss on heating	12·41	Cl_2 12·01

A solution 35^{cc} in volume, made of equal volumes of concentrated hydrochloric acid and water, and containing ·0619^g of rubidium and double the theoretical quantity of lead chloride was saturated with chlorine. A precipitate of the double salt was produced, which, after standing several

hours was collected upon a Gooch filter. The rubidium in this precipitate was determined and found to amount to ·0318^g. One cubic centimeter of the solution dissolved, therefore, ·003^g of the lead salt, equivalent to ·00086^g of rubidium. The experiment was made at about 20°.

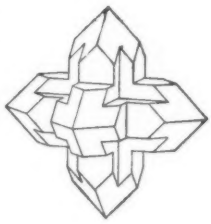
Cæsium-Plumbic Chloride, Cs_2PbCl_6:—This salt is very readily prepared by passing chlorine into solutions containing lead chloride and a large excess of cæsium chloride. When hydrochloric acid is present, the excess of cæsium chloride is unnecessary, but in that case the precipitate is very finely divided. The precipitate begins to form in solutions that are nearly at a boiling temperature. A crop obtained without the use of hydrochloric acid was analyzed. It was washed with hydrochloric acid containing chlorine and air-dried.

	Found.		Calculated for Cs_2PbCl_6.
Cæsium	38·51		38·78
Lead	30·05		30·17
Chlorine	30·99		31·05
	99·55		100·00
Loss on heating	10·96	Cl_2	10·35

The salt usually has a lemon-yellow color, but, when very strong hydrochloric acid is used and a large excess of lead chloride is present the precipitate has a dark brown color. Such a crop gave the following analysis:

	Found.		Calculated for Cs_2PbCl_6.
Cæsium	38·19		38·78
Lead	29·64		30·17
Chlorine	31·35		31·05
	99·18		100·00
Loss on heating	11·09	Cl_2	10·35

This is evidently the same compound as the lemon-yellow salt. The cause of the brown color is not known. The presence of lead dioxide in it does not seem probable on account of the strong acid that was used, and, moreover, experiment showed that this oxide was instantly dissolved by the mother-liquor. It was suspected that this was a dimorphous form of the compound, but Mr. Louis V. Pirsson, who has kindly made a microscopic examination of both products, has found that both are isometric and octahedral in habit. He noticed that while the yellow salt forms perfect octahedrons, the brown compound occurs in octahedral



groups composed of combinations of the cube and octahedron. The accompanying figure, by Mr. Pirsson, shows the prevailing habit of these crystals. The groups are very small, usually not over 0·015^{mm} in diameter.

Sheffield Scientific School, March, 1893.

ART. XXVII.—*On a Method for the Quantitative Determination of Cæsium, and the Preparation of Pure Cæsium and Rubidium Compounds;* by H. L. WELLS.

SINCE no method has heretofore been devised for the accurate quantitative determination of cæsium in the presence of both rubidium and potassium, some experiments have been made in order to test the availability of the plumbic chloride, described in the preceding article, for this purpose. The results have not been as accurate as could be desired, but the method will be useful until a better one is found.

The solubility of Cs_2PbCl_6 in a hydrochloric acid solution (fuming acid diluted with water 1:1), containing twice the theoretical amount of lead chloride and saturated with chlorine, was determined by making a precipitation of about 1^g of Cs_2PbCl_6 under these conditions in 350^{cc} and determining the cæsium in the filtrate. The whole filtrate gave 0·0119^g of Cs_2SO_4, which corresponds to a solubility of 0·000068^g of Cs_2PbCl_6 in 1^{cc}. A similar experiment in which concentrated hydrochloric acid was used, and also a larger excess of lead chloride, gave a solubility of 0·000049^g of Cs_2PbCl_6 in 1^{cc}. It has been shown in the preceding article that the solubility of Rb_2PbCl_6 is 0·003^g in 1^{cc} under similar conditions.

Some actual determinations of cæsium were made as follows: Known quantities of Cs_2PbCl_6 and about an equal weight of $PbCl_2$ were dissolved in hot HCl (1:1). Chlorine was passed into the solutions until they became cold, and, after standing about three hours, the precipitates were collected in porcelain Gooch crucibles and washed with hydrochloric acid containing chlorine. The precipitates were decomposed with hot water and the cæsium in the resulting solutions was determined as sulphate. In one case a comparatively large amount of potassium chloride was present. The details are as follows:

	Cs_2PbCl_6 taken.	KCl taken.	Volume 1:1 HCl.	Cs_2SO_4 found.	Deficiency as Cs_2SO_4.
A	·1674^g	----	35^{cc}	·0856	·0026
B	·1592	----	35	·0807	·0031
C	·1280	0·5^g	35	·0638	·0035

These results indicate greater errors than were expected from the previous solubility determinations. It is suspected that a little of the precipitate was dissolved by washing, and the use of hydrochloric acid containing lead chloride as well as chlorine would probably diminish the error. The last experiment shows that the presence of a considerable amount of potassium has no influence upon the result.

The determination of cæsium by this method can be simplified by weighing the precipitated cæsium-plumbic chloride directly. The salt is perfectly stable at 100°. The following table gives the details of a number of determinations made in this way. The precipitates were all thoroughly washed with hydrochloric acid containing chlorine and dried on an asbestus filter at 100°.

	Cs_2PbCl_6 taken.	$PbCl_2$ taken.	KCl taken.	Volume HCl.	Cs_2PbCl_6 found.	Cs_2PbCl_6 lost.
A	·2761^g	0·25^g	...	28^{cc} 1 : 1	·2650^g	·0111^g
B	·0878	1·0	0·5^g	52 1 : 1	·0833	·0035
C	·1202	1·0	...	52 1 : 1	·1071	·0131
D	·7558	0·1	...	28 conc.	·7369	·0189
E	·2483	0·1	...	20 conc.	·2359	·0124

The results show considerable losses in cæsium, which apparently do not entirely depend upon the volume in which the precipitation is made. It is believed that the losses occur chiefly in washing, for large quantities usually show a larger total loss than small ones.

When cæsium and rubidium are together, the precipitation of cæsium plumbic chloride is accompanied by a partial precipitation of the rubidium, unless the quantity of the latter is small. It is possible, however, to make an indirect determination of the cæsium in such a precipitate by weighing it and afterwards determining the weight of the cæsium and rubidium sulphates. Two experiments have been made on this plan, where not only rubidium, but also potassium, sodium and lithium were present.

	A	B
Cs_2PbCl_6 taken,	0·3561^g	0·1545^g
Rb_2PbCl_6 taken,	0.2845	0·4101

To each of these were added about 0·15^g each of potassium and sodium chlorides, 0·25^g of lithium carbonate and 0·1^g of lead chloride. The substances were dissolved by boiling with dilute hydrochloric acid, about an equal volume of concentrated acid was added, and chlorine was passed until the solutions became cold.

	A	B
Volume of solution,	30^{cc}	50^{cc}

After standing several hours the precipitates were collected on asbestus filters in porcelain Gooch crucibles, washed with dilute hydrochloric acid saturated with chlorine, dried at 100° and weighed.

	A	B
Cs_2PbCl_6 and Rb_2PbCl_6 found,	0·5621	0·4538

The precipitates were treated on the filters with hot water, the resulting solutions were evaporated with sulphuric acid, the lead sulphate was removed by filtration, the filtrates were evaporated and finally ignited in an ammoniacal atmosphere and the mixed sulphates were weighed.

	A	B
Cs_2SO_4 and Rb_2SO_4 found,	0·2826	0·2164

For calculating the results, the following formulæ were used:

(P = weight of $Cs_2PbCl_6 + Rb_2PbCl_6$)
(S = weight of $Cs_2SO_4 + Rb_2SO_4$)
Weight of $Cs = 5{\cdot}095S - 2{\cdot}301P$
Weight of $Rb = 2{\cdot}006P - 3{\cdot}801S$

	A	B
Cæsium taken	0·1381	0·0599
Cæsium found	0·1464	0·0584
Error in cæsium	0·0083+	0·0015−
Rubidium taken	0·0823	0·1186
Rubidium precipitated	0·0534	0·0876

The results show that approximate determinations of cæsium can be made by this method when all the alkali-metals are present. The process leaves a part of the rubidium with the potassium, and these two metals can be precipitated as platinic chlorides and their amounts determined indirectly.

The method which has been described is useful for the extraction of cæsium and rubidium from their natural sources. The following method of procedure may be suggested, supposing all the alkali-metals to be present as chlorides in a concentrated aqueous solution:

At least an equal volume of concentrated hydrochloric acid is added, and any precipitated sodium and potassium chlorides are removed. The solution is diluted somewhat to avoid a subsequent precipitation of these chlorides, a solution of lead chloride, made by boiling lead oxide with a large excess of hydrochloric acid, is gradually added while chlorine is passed into the solution until it is cold and until fresh additions of lead chloride fail to produce a yellow precipitate. According to my solubility determinations, this precipitation leaves less than 1^g of rubidium and a much smaller quantity of cæsium in each liter of the solution. The precipitate is usually almost

free from potassium. To ensure the complete purification of the cæsium and rubidium, the precipitate is washed with hydrochloric acid containing chlorine and lead chloride, then it is treated repeatedly with small quantities of boiling water until completely decomposed, and the resulting solution is subjected to a repetition of the foregoing process. The mixed plumbic salts are decomposed with hot water and the resulting, filtered solution is evaporated to dryness to remove hydrochloric acid. The residue is dissolved in hot water,* the lead is precipitated by the addition of a slight excess of ammonium sulphide and the precipitate is removed by filtration. The solution is evaporated to dryness and the residue consists of cæsium and rubidium chlorides and some ammonium chloride.

The following directions for the separation and purification of the cæsium and rubidium do not involve any new methods, but the course of procedure has been arrived at after a considerable amount of experience, and it may be of use to others. It is assumed that rubidium is more abundant than cæsium in the mixture. If cæsium predominated it would be more advantageous to extract that metal first by an obvious modification of the process.

The mixed chlorides of rubidium and cæsium are dissolved in at least five parts of concentrated nitric acid and the solution is evaporated to dryness and heated until the excess of nitric acid is removed. The residue is dissolved in a small amount of water, and as much oxalic acid as corresponds to twice the weight of the original chlorides is added. The whole is evaporated to dryness and the residue is ignited in platinum until the oxalates are completely converted into carbonates.† The carbonates are dissolved in water, the solution is filtered and exactly neutralized with a measured solution of tartaric acid, as much more tartaric acid as has been used for the neutralization is added, and the solution is evaporated until it becomes saturated while hot. The solution on cooling deposits acid rubidium tartrate, which is washed with a small quantity of water and is recrystallized two or three times from a hot saturated solution in the same way until it gives no cæsium spectrum.‡ The united mother-liquors from the acid rubidium tartrate are evaporated to dryness and ignited in platinum. The resulting carbonates are converted into chlorides, and, to a solution of these in a small volume of 1 : 1 hydrochloric acid, a solution of antimony trichloride in the same acid is

* No part of this residue should be thrown away on the assumption that it is lead chloride, for the salt $CsPb_2Cl_5$ is difficultly soluble and resembles $PbCl_2$.

† This method of converting alkaline chlorides into carbonates is due to J. L. Smith, this Journal, II, xvi, 373.

‡ This method is due to O. D. Allen, this Journal, II, xxxiv, 367.

added as long as a precipitate forms.* The precipitate is collected on a filter and washed with hydrochloric acid. To remove traces of rubidium, the precipitate is thoroughly decomposed with successive, small quantities of hot water, then hydrochloric acid and a little antimony trichloride are added to the whole in order to repeat the precipitation. The last precipitate is washed with hydrochloric acid. It usully shows no rubidium when tested with the spectroscope. The cæsium antimony chloride is decomposed with hot water and hydrogen sulphide is passed into the resulting solution. The filtrate from the antimony sulphide gives, on evaporation, pure cæsium chloride. The filtrates from the antimony double salt are freed from antimony, evaporated to dryness and the mixture of cæsium and rubidium chlorides, which should be very small in amount, is preserved for use in subsequent purifications.

Sheffield Scientific School, April, 1893.

Art. XXVIII.—*On some Peculiar Halides of Potassium and Lead;* by H. L. Wells.

In a preceding article I have described a series of double chlorides of the type M_2PbCl_6, where M is NH_4, K, Rb and Cs. It has seemed desirable to extend the investigation by attempting to prepare bromides and iodides corresponding to these salts. A thorough search has been made, using the metals of the potassium group and sodium, with the result that no double bromides or iodides containing extra halogen could be prepared except in the case of potassium. It is remarkable that the potassium-lead bromide and iodide which have been discovered do not correspond in composition to the chlorides. The failure to prepare double salts of rubidium and cæsium corresponding to the new potassium compounds was unexpected, for, as a general rule, the insolubility and stability and the consequent ease of preparation of such compounds become greater from potassium towards cæsium. The explanation of the anomaly probably lies in the fact that extremely concentrated rubidium and cæsium solutions containing a lead halide and the corresponding halogen cannot be obtained, in the case of the bromides and iodides, on account of the slight solubility of cæsium triiodide, and of the double halides which are formed with $PbBr_2$ and PbI_2.

The compounds to be described probably have the composition represented by the following formulæ:

* Method of Godeffroy, Berichte, vii, 375.

$$K_3Pb_2I_8.4H_2O$$
$$K_3Pb_2Br_8.4H_2O$$

These formulæ may be also written,

$$3KI.2PbI_3.I.4H_2O \text{ and } 3KBr.2PbBr_3.Br.4H_2O.$$

The composition of these salts is very remarkable on account of the small amount of the extra halogen that they contain. They apparently do not correspond to any other chemical compound that is known.

The Iodide, $K_3Pb_2I_8.4H_2O$: — This salt forms brilliant, black, prismatic crystals, sometimes a centimeter or two in length and three or four millimeters in diameter. Although the crystals have fine prismatic faces, they never appear to have definite terminations. The ends usually appear fibrous, as though made up of numerous small crystals in parallel position. When the crystals are crushed on paper it is evident that they enclose much mother-liquor. The salt is deposited from nearly or quite saturated solutions of potassium iodide containing lead iodide and iodine. It is deposited at ordinary temperature, usually slowly, after the lapse of several hours or even after several days. In preparing the compound, the lead iodide and the iodine can be varied considerably, but it is formed only in very concentrated potassium iodide solutions and it is difficult to obtain crops of it which are not evidently contaminated with this salt in the form of crystals. The salt is stable in the air but it is instantly decomposed by water or alcohol, so that it cannot be washed.

Six separate crops have been analyzed, and great care has been used in selecting them and in drying them on paper for analysis. In two cases the product was rapidly and finely pulverized during the drying operation, but without any effect upon its composition. The results of the six analyses agree with remarkable closeness, but in spite of this fact it must be assumed, from considerations which will be given subsequently, that all these products were seriously contaminated with potassium iodide. The fibrous nature of the crystals and the concentration of the mother-liquor make the possibility of such a contamination very evident, but the constancy of this contamination, as indicated by the uniformity of the analyses, is very remarkable in view of the fact that some of the products were made at wide intervals of time, covering a period of about six months, so that there were considerable variations in the laboratory temperature.

The products were made under the following conditions:

	KI	PbI_2	I	Volume.
A	450g	30g	15g	?
B	425	30	50	450cc
C	445	40	70	470
D	445	40	100	470
E	445	40	150	460
F	200	15	15	200

They gave the following results on analysis:

	K	Pb	I	H_2O	
A	9·31	22·03	64·00	4·69	= 100·03
B	9·25	22·30	----	4·81	
C	9·07	22·03	63·98	4·89	= 99·97
D	9·21	21·98	64·09	4·71	= 99·99
E	9·20	22·13	64·17	----	
F	9·27	22·02	63·84	----	

In these analyses and those which follow, water was determined by weighing it directly in a calcium chloride tube. The other determinations were made according to the methods mentioned in the preceding article on the double salts of lead tetra-chloride.

The above analyses correspond closely to the formula $K_3Pb_4I_{19}.10H_2O$, but it will be shown beyond that the probable formula of the pure compound is $K_3Pb_2I_8.4H_4O$. This requires K=7·25, Pb=25·56, I=62·74 and H_2O=4·45. If this is the true composition, it must be assumed that all of the analyzed products were contaminated with about 16·5 per cent of potassium iodide, and that an excess of water was present, possibly on account of the hygroscopic properties of that salt.

It is to be noticed that the products were prepared under great variations in the amount of iodine present, and it can be safely assumed, from the care with which the products were examined, that they were not contaminated with the salt $KPbI_3.2H_2O$ nor any similar compound. The amount of lead iodide in the solutions was comparatively small, and a large part of it was used in forming the salt under consideration, so that any contamination must have been chiefly potassium iodide. It is therefore evident, since the salt is not decomposed on exposure, and since the analyses show a constant amount of extra iodine in spite of the variations of this ingredient in the solutions, that the analyses must show the true ratio between the lead iodide and the extra iodine in the pure compound. This ratio is $2PbI_2$:I in both $K_3Pb_4I_{19}$ and $K_3Pb_2I_8$.

The Bromide, $K_3Pb_2Br_8.4H_2O$:—This compound forms dark brown, prismatic crystals which are solid and definitely terminated, so that they do not have the tendency to hold inclosed mother-liquor which the iodide has. The salt is easily

prepared and it crystallizes well, but it is extremely unstable. When exposed to the air it begins to whiten almost instantly, giving off bromine. It is stable, however, in air containing a considerable amount of bromine vapor, so that it can be dried by pressing on paper in such an atmosphere. It is sufficiently stable, when corked up in a weighing-tube, to be rapidly weighed in a cold room without serious decomposition.

Three crops of the double bromide were analyzed. A and B were made, in each case, by adding 20^{cc} of bromine to 400^{cc} of a cold solution which was saturated with potassium bromide and lead bromide and allowing the mixture to stand over night. C was made like the other crops, except that 30^{cc} of bromine were used.

	Found.			Calculated for
	A	B	C	$K_2Pb_2Br_6.4H_2O$
Potassium	10 33	10·41	10·24	9·43
Lead	32·05	31·90	32·49	33·30
Bromine	51·96	52·15	52·05	51·48
Water	----	5·59	5·28	5·79
		100·05	100·06	100·00

The analyses agree with the formula as well as could be expected, considering the instability of the compound. The analyses show almost exactly one atom of extra bromine for two atoms of lead, so that the compound is closely related to the iodide if not exactly analogous to it.

The satisfactory crystals of the bromide and the stability of the iodide suggested the possibility that, if the two compounds were really analogous as suspected, isomorphous mixtures of the two could be made which would retain the desirable qualities of both, so as to be solidly crystallized and stable enough to be accurately analyzed. Experiments showed that isomorphous mixtures could be readily obtained which crystallized satisfactorily, and it was found that even small amounts of iodine had the effect of greatly increasing the stability of the compound. It was noticed that when a product was made from a solution containing free bromine and iodine in nearly atomic proportions (BrI), an almost perfectly stable, bright red salt was obtained. The color of this salt is far from being intermediate between that of the black iodide and the dark brown bromide, but, since the analyzed products contain about 23 atoms of bromine to one of iodine, it does not seem probable that any definite relation between the two halogens exists. It is remarkable that such a small proportion of iodine should have so great an influence upon the color and stability of the product, but it is to be noticed that only one eighth of the

halogens in these compounds is in excess, so that, if all the iodine is in this condition it amounts to about one-third of this excess.

The crops A and B had a dark bronze color. They were successive crops made by adding bromine to a strong solution of potassium iodide containing lead iodide. The exact conditions are unknown, but it is probable that insufficient bromine was used to set free all the iodine which the solution contained. These products were apparently as stable as the iodide.

C and D were successive crops made by continuing the addition of bromine to a somewhat similar solution until a change of color showed that the free iodine had been converted into BrI. These salts were red. An analysis of the mother-liquor from D gave, $KBr = 31{\cdot}3$, $PbBr_2 = 1{\cdot}8$, $Br = 6{\cdot}7$, $I = 8{\cdot}3$, H_2O(difference) $= 51{\cdot}9$.

E was made by adding 31^g of bromine to 430^g of the above-mentioned, analyzed solution. This crop was also red, but it was not quite as bright in color and not as stable as the others. On continuing the addition of bromine, still less stable crops were obtained which approached the pure bromide in color. These were not analyzed.

The analyses of the five crops are as follows:

	K	Pb	Br	I	H_2O	
A	9·41	31·57	41·40	12·06	5·09 =	99·53
B	9·24	31·55	39·27	14·57	----	
C	9·90	32·88	48·66	3·40	5·24 =	100·08
D	9·99	32·74	48·70	3·30	5·02 =	99·75
E	10·24	32·26	49·97	2·07	----	

The ratios calculated from the above analyses are as follows:

	K	:	Pb	:	Br+I	:	H_2O
A	1·57		1·		3·99		1·83
B	1·55		1·		3·99		----
C	1·59		1·		4·00		1·82
D	1·61		1·		4·00		1·76
E	1·68		1·		4·16		----

The ratio required for the formula $K_2Pb_2(Br,I)_5.4H_2O$ is,

K	:	Pb	:	Br+I	:	H_2O
1·50		1·		4·		2·

The analyses agree well with this formula, except that the water is somewhat low. Although $3\frac{1}{2}$ molecules of water would correspond more closely to these analyses than 4, the latter number is considered more probable on account of the fact that the analyses of the iodide show some excess over four molecules.

It is to be seen that these mixed salts correspond in composition to the bromide. The analogous mode of formation of the iodide, the identical relation of the lead to the extra halogen in the iodide and the other products, as well as the existence of these mixed salts, make it appear certain that the analyzed iodide was invariably impure and that the pure compound should be considered as analogous to the other salts. This view has been confirmed by a crystallographic examination of the iodide and the red bromo-iodide, which Prof. S. L. Penfield has kindly undertaken. He has found that both these salts crystallize in prisms of the tetragonal system. Unfortunately the crystals of the iodide were without terminations, so that a more detailed comparison of the two salts could not be made.

The nature of these peculiar salts is not clear. If they are, strictly, hydrous "double salts," such higher halides as Pb_2I_5 or K_2I_4 must be assumed. If they are formed from such compounds as PbI_4 or KI_3, they must be considered as hydrous triple salts.

Sheffield Scientific School, April, 1893.

ART. XXIX.—*On the Oscillations of Lightning discharges and of the Aurora Borealis;* by JOHN TROWBRIDGE. (With Plate IV.)

IT is well known that when air is subjected to a sudden strain at the moment of an electrical discharge it acts like glass or a similar elastic solid and is cracked in zigzag fissures: indeed the resemblance between the ramifications of lightning and the seams produced in plates of glass by pressure has been commented upon by various observers. Photographs of powerful electric sparks lead one to conclude that a discharge of lightning makes way for its oscillations by first breaking down the resistance of the air by means of a disruptive pilot spark; through the hole thus made in the air the subsequent surgings or oscillations take place.

In examining the early photographs of electric sparks by Feddersen one perceives indications that the electric oscillations tend to follow for at least some hundred thousandths of a second the path made by the pilot spark; and there are observers who believe that by rapidly moving a camera they have obtained evidence that successive discharges of lightning follow the same path. Professor Lodge has protested, with reason, against the conclusions drawn from the method of "waggling" the head or camera: for the movement of the

head or camera certainly requires the hundredth of a second while the discharge of lightning is over in less than one hundred thousandth of a second.

The method of the photography of electrical discharges by means of a revolving mirror seems to be the best method of studying the behavior of air suddenly subjected to the electric strain. I have therefore examined this behavior with more powerful means than those employed by previous observers; and it may be well to recall here the fact that usually in lightning discharges, high electromotive force and great quantity are frequently combined in a very short interval of time. The modern alternating machine and the device of the transformer enables one to study the character of lightning more successfully than is possible by means of an electrical machine: for both the electromotive force of the discharge and its quantity can be adjusted over a wide range. In my study of this subject I employed an alternating machine giving from three hundred to four hundred alternations per second, with a current from fifteen to twenty amperes, and the photographic apparatus was the same as that which was used in my investigation on the damping of electrical oscillations on iron wires.* By means of a step-up transformer and an oil condenser, discharges of high electromotive force and great quantity could be readily obtained. The method of the excitation of a Ruhmkorf coil or transformer by means of an alternating dynamo, due originally to Spottiswode, has placed in the hands of the experimenter, as I have said, powerful means of studying electrical discharges.

Since my object was to study the photographs of sparks having both great electromotive force and great quantity I limited myself to discharges of about two centimeters. By the device of an air blast and other contrivances for obtaining a quick break in the continuity of the electrical discharges, Professor Elihu Thompson has shown how sparks of many feet in length can be obtained. Figures 1 and 2 are reproductions from untouched negatives not enlarged, and ten to twelve oscillations can be counted on each photograph. The interval between the oscillations is about one hundred thousandth of a second; and it will be noticed that the electrical discharge follows exactly the same path in the air for three hundred thousandths of a second. During this length of time every sinuosity in the air path is exactly reproduced. I employed terminals of tin; and on figure 1 it will be noticed that a mass of melted and vaporized tin remained suspended in the air for at least three hundred thousandths of a second before it was dissipated in a comet-like tail. During the three hun-

* Phil. Mag., Dec., 1891.

dred thousandth of a second, therefore, the air remained passive while the electrical oscillations took place. During this time it is fair to conclude that the heat produced by the passage of the spark was not sensibly conducted away. If conduction of heat had taken place the electrical resistance of the air path would have been sensibly altered and the path of the discharge would have changed in form. Here I think we have an interesting limit to the time it takes atmospheric air to respond to the phenomenon of heat conduction.

I have said that the discharges I employed were powerful both in regard to electromotive force and to quantity. Iron terminals one-quarter of an inch in diameter were raised to a white heat by the continuous passage of the sparks and globules of the melted metal were formed. When the sparks were passed through the secondary of a transformer of about thirty seccohms of self induction, three fifty-volt Edison lamps placed in multiple in the primary of the transformer, which consisted of merely two layers of thick wire, were lighted to full incandescence. The spark from two large glass condensers of 5000 electrostatic units each, excited by an electrical machine, passed through the same step-down transformer barely raised a six-volt lamp to a red heat. The study of the efficiency of step-down transformers in thus transforming transient currents of high potential to transient currents of low potential and comparatively large current enables one to obtain an estimate of the high potential of lightning and of the current which accompanies its fall of potential. Thus if C denotes the current in the lightning discharge and E the electromotive force, C′ and E′ the corresponding quantities in circuit of the primary of the step-down transformer and A the efficiency of the transformer we shall have

$$C'E' = ACE$$

The element of time and the mode of transformation must be considered in any estimate of the amount of energy in lightning discharges. Although a powerful spark of electricity from two Leyden jars each of 5000 electrostatic units is incapable of decomposing water directly; yet by its passage through the secondary of a suitable step-down transformer it can decompose the water in the primary with great evolution of gases, and it is probable that an ordinary discharge of lightning of a few hundred feet in length could light, for an instant, many thousand incandescent lamps if it were properly transformed by means of a step-down transformer. Indeed the ringing of electrical bells and the melting of electrical fuses are of common occurrence during thunder storms and manifest the energy of lightning discharges. During a recent visit at a

summer hotel which was lighted by incandescent lamps, I was much interested to observe that the lamps blinked at every discharge of lightning, although the interval which elapsed between the blinking and the peals of thunder showed that the storm was somewhat remote. This effect was doubtless due to induction produced by the surging of the lightning discharges. On the occasion of a heavy discharge the lights were completely extinguished, although no fuse was burned. My observation of this effect of lightning upon electric light circuits also leads me to believe that the system of carrying electric light wires along gas fixtures where both gas fixtures and electric light fixtures are combined is fraught with great danger. If there is a leakage of gas at the joints of the gas pipes or through a sand hole in the casting of the pipes electric sparks arising through resonance effects or from ordinary passage to earth of an electric charge brought into the building by the electric wires can ignite the escaping gas and produce a mysterious conflagration. Such a conflagration was averted in the hotel in which I noticed the blinking of the lamps only by the careful scrutiny of an attendant who noticed a jet of gas from a pin hole in the gas fixtures impinging on the wood work. During the storm a minute electric spark had ignited the escaping gas. Electric light wires and gas pipes should never be contiguous; for no lightning guard or protector can ensure that minute sparks, due in some cases to resonance effects, may not arise.

The study of the disruptive or oscillatory discharge of lightning is closely connected with that of the brush discharge and that of the phenomenon of the Aurora Borealis; for the disruptive discharge if it is an oscillatory discharge ceases to be disruptive after a few hundred thousandths of a second, as figures 1 and 2 show, and partakes of the nature of a brush discharge. The zigzag fissures in the air disappear and only the spark terminals glow. Recent experimenters have exhibited, as a marvel, the lighting of a vacuum tube through the human body by grasping one terminal of a suitable transformer with one hand and by holding the vacuum tube in the other hand. It must be remembered, however, that the lines of force proceed from the hand which holds the vacuum tube through the air and the walls or floor of the room to the other terminal of the transformer. We can change this brush discharge or luminosity at either terminal of a transformer into a disruptive discharge by lessening the distance between the terminals or by increasing the electromotive force.

I am fully aware that the oscillatory discharge of lightning with its disruptive effects I have noted—its permanence of path and the fading of the disruptive discharge into the brush

discharge or mere luminosity at either of the spark terminals, is a far simpler phenomenon than the luminosity produced in rarefied tubes; for in the latter phenomenon we have the dissociation and impact of molecules, and we must consider all the problems of atomic motion in addition to those of the oscillatory nature of electrical waves. It is not my purpose to enter into a consideration of the molecular movements involved in oscillatory discharges in vacuum tubes; but having discussed some of the general features of discharges of electricity in air at the ordinary pressure I shall endeavor to trace the connection between such discharges and the phenomenon of the Aurora Borealis. To my mind the luminosity in a vacuum tube held in one hand while the other hand grasps the terminal of a Ruhmkorf coil, closely represents the phenomenon of the northern light, for we have in this case a discharge of electricity from a higher level to a lower through a rarified medium. Although in this paper I restrict myself to a discus sion of the general relations between discharges of lightning and the phenomenon of the Aurora Borealis, and do not enter into a study of the molecular movements excited by electrical discharges, I am impelled to devote a few words to the subject of the stratified discharge and to show that it has no connection with the oscillatory discharge of electricity such as we are considering. The distances between the stratifications do not seem to be changed by modifying the period of forced oscillation given to the transformer over a wide range. I have produced the stratifications by employing an interrupter of a Ruhmkorf coil giving from sixty to one hundred vibrations per second, and by the use of two alternating machines, one giving 300 to 400 alternations per second and the other 900 to 1000 alternations per second. The distances between the stratifications do not seem commensurate with the rate of alternation of the exciter of the transformer. On the other hand the distance between the stratifications is not dependent upon the amount of self induction in the circuit. In one case quadrupling the self induction reduced the distance between the stratifications one-half. This reduction was due not to the increased self induction but to the increased resistance; for the introduction of a water resistance of some megohms diminished in a similar manner the distance between the stratifications. In short I could not discover any connection between the law $t = 2\pi\sqrt{LC}$ and the phenomenon of stratification.

I have said that we can pass by insensible gradations from the condition of the brush discharge to that of the disruptive discharge. By intercalating a non-inductive water resistance and a vacuum tube between the terminals of a suitable transformer we can exactly imitate the phenomena observed when

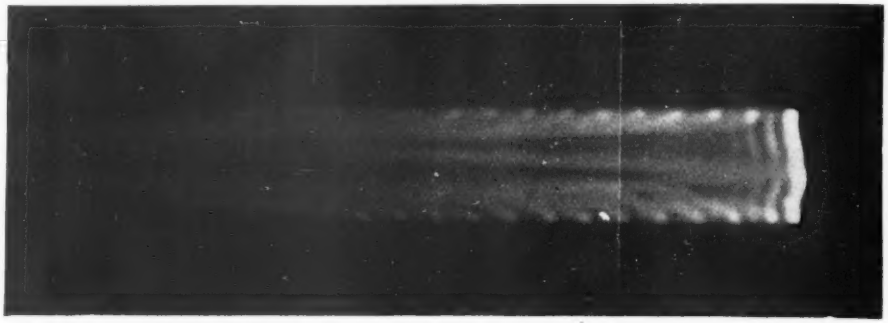
the vacuum tube is held in one hand while the other hand grasps one terminal of the transformer. In this case the water resistance takes the place of the resistance of the air of the room. The intensity of the discharge being thus much diminished one can readily study various manifestations of stratification which may perhaps be termed transitory stratifications in distinction to the stationary wave-like forms observed in narrow tubes. The transitory stratifications can be produced at will by touching suitable points of a vacuum tube with the finger or by connecting such points with the ground. Such stratifications are stationary as long as the ground connection is maintained, and are independent of the rate of the alternating machine which excites the transformer. It is evident that the condenser action of the vacuum tube plays an important part in this phenomenon. In observing the striæ and waving columnar form of the light excited in this manner in tubes filled with rarefied gases, one is led to believe that the stratified form of the Aurora Borealis is produced in a similar manner. Fig. 3 is a form of the northern light noticed by me. Let us suppose that a discharge of electricity takes place in rarefied air between A and B, and that C is a region of cloud or moisture. C can be regarded as the finger or earth conductor which is applied to the tube of rarefied air and which seems to throw the discharge into transitory stratification, and to give the waving form of the Northern light.

The pulsation, therefore, of the Aurora Borealis is in no way, I believe, connected with any oscillatory discharge; yet certain writers have intimated that the glowing of vacuum tubes which are connected with one terminal of a transformer and the light of the Aurora is due to millions of electrical oscillations per second. Now it is impossible to study the question of the rate of oscillation of the brush discharge, by means of Federsen's method for the light of the discharge is not sufficient to produce a photograph. A brief consideration, however, of the laws of electrical oscillations shows, I think, that such writers are mistaken. The rate of decay of the amplitude of such oscillations is expressed by the well known factor

$$E^{-\frac{Rt}{2L}}$$

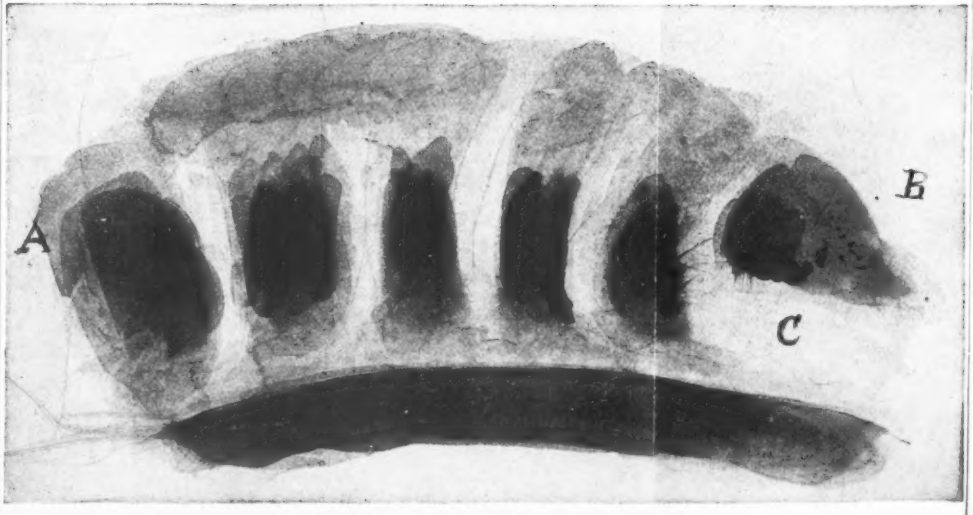
Now in the case of a brush discharge R is enormously large. A resistance of thirty or forty ohms was sufficient to completely damp the oscillations of the sparks studied by me in the research on the damping produced on iron wires. In the

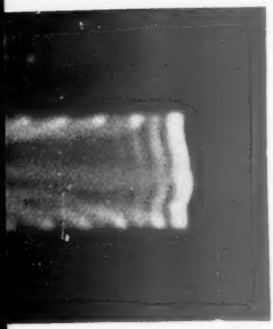
1.

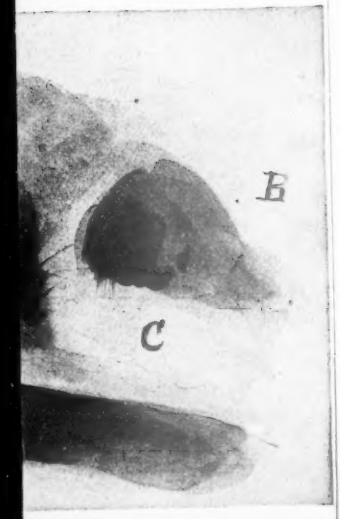


2.

3.






B
C

case of the brush discharge although we may be dealing with very small values of self induction and small values of time, we have on the other hand great values of R. I believe therefore that the brush discharge is reduced to the case of one throb which is analogous to the pilot spark in disruptive discharges. In regard to the Aurora, it may be urged that the resistance of the rarified air is not enormous. In answer to this, it can be said that the phenomenon of the Northern light can be best reproduced by intercalating a tube of rarefied air with some megohms of a water resistance between the terminals of a suitable transformer. The supposition that the Northern light is produced by the action of extremely rapid electrical oscillations on molecules of rarefied air is not borne out by the theory of transient currents and experiment shows that the phenomenon of the waving and apparent stratification observed at times in the Aurora is due to the re-distribution of the lines of force which is produced by suitable earths in the shape of regions of cloud and moisture.

The comparatively small resistance of the electric spark in air noticed by many observers is due I believe to the permanence of path, for this path is intensely heated and is practically a charred hole in the air. When this path no longer becomes such a hole and the heated air rises and is dissipated, the oscillations of the electric spark become rapidly damped, and we have the phenomenon of the glow at each of the spark terminals without the disruptive discharge; that is, we perceive what is termed a brush discharge. The lines of force crowding from one terminal seek through the air of the room the other terminal, and in passing through rarefied air the energy along the lines of force is manifested by molecular actions which are apparently protean in form. I see therefore no evidence for believing in the rapid oscillation of the Aurora.

Jefferson Physical Laboratory, Cambridge, Mass.

ART. XXX.—*The Auriferous Veins of Meadow Lake, California;* by WALDEMAR LINDGREN.

General type.—Fissure veins containing auriferous sulphides and arsenides with gangue of tourmaline, quartz and epidote in granitic and diabasic rocks.

By far the larger part of the veins of the gold belt of California have a gangue of quartz alone or quartz with some

dolomite or calcite,* contain free gold besides sulphides, and occur in the sedimentary auriferous slate series or in the eruptive bodies, unaltered or dynamo-metamorphosed, which are connected with them; the large granitic areas are usually barren. The group of veins to be described here shows thus a type which in many respects differs from the ordinary. Indeed, auriferous deposits of this class do not appear to have been mentioned as occurring in any other part of the United States.

Location and discovery.—The Meadow Lake mining district is situated in Nevada County about ten miles north of Cisco, a station on the Central Pacific Railroad at elevations ranging from 7000 to 7500 feet. The first divide of the Sierra Nevada whose summits here reach 9000 feet, is only eight miles distant towards the east. The climate is severe and snow sometimes falls to a depth of twenty feet on the level. A rough trail leads into the district from Cisco; a wagon road thirty-five miles long leads to Truckee by a circuitous route.

The mines were discovered in 1863 by H. H. Hartley, and a great rush took place to the district in 1865 and 1866. The free gold found at the surface soon gave way to relatively poor sulphides and the boom speedily collapsed. At various times subsequently some work had been done on the principal mines and only recently the deposits have been subject of some discussion in the technical papers. Considering the difficulties of access and climate, there is some doubt as to whether any of the deposits can ever be worked with profit. The ores will not average more than from seven to ten dollars per ton at the most. Probably $200,000 or $300,000 have been expended in the district, while it is doubtful if more than $75,000 have been taken out.

General Geology.—The area shown in the sketch map (p. 204) is of a rough mountainous character, the elevations ranging from 5,800 to 7,800 feet. The vegetation is scant, the soil having been swept away by the Pleistocene ice sheet once covering the region, leaving enormous bare expanses of the prevailing granitic rock.

Granodiorite.—A light gray granitic rock occupies the larger part of the area of the map and in it is contained nearly all of the veins. The rock is in general identical with the gray so-called granite that occupies such large areas in the

* In a footnote in an article on "The Gold deposit at Pine Hill" (this Journal, August, 1892) regarding gold in calcite and dolomite I omitted to mention that such occurrences had first been noted by Prof. W. P. Blake from Mariposa and Amador Counties, Cal. Annot. Catal. on the principal mineral species of California." Sacramento, 1866.

Sierra Nevada and which probably extend through southern California far down into the peninsula of Baja California *

The rock consists in typical development of feldspar, quartz, biotite and hornblende with medium grained hypidiomorphic structure. The soda-lime feldspars are usually considerable and to a variable extent in excess of the alkali feldspars. The silica varies between 60 and 73 per cent; the amount of lime is variable, but it rarely exceeds while it usually falls somewhat short of the sum of the alkalies. While in some varieties which cannot be distinguished from the others in the field, there is more potash than soda, a frequently occurring relation is 2 per cent Ka_2O to 4 per cent Na_2O. It will be seen that the rock very closely approaches some quartz-mica-diorites and often might be indicated by that name.†

This term, however, besides being clumsy, does not sufficiently express its close relationship to granite, brought out by its frequently high percentage of silica and low percentage of lime, by its variable percentage of alkali feldspars and by the muscovite sometimes occurring in it. On the Survey maps of the Gold Belt of the Sierra Nevada, of which district Mr. G. F. Becker is geologist in charge, it has therefore been determined to indicate this rock as *granodiorite*, which term it is hoped will find general acceptance.

Age of the granodiorite.—The granodiorite is later than the quartzitic slates of Signal Peak or Red Mountain north of Cisco, which have been extensively metamorphosed by it. As these sedimentary rocks are the direct continuation of the series which a few miles farther south at Sailor Cañon have been identified as Jura-Trias from the meagre fauna occurring in them, the granodiorite evidently postdates that period.

At Meadow Lake several interesting facies of the granodiorite occur. Near the diabase contact it appears darker and more basic by increasing hornblende. West of Meadow Lake from the Keystone mine up towards French Lake there is no biotite, but at many places a monoclinic pyroxene appears and the rock contains abundant titanite. At several places near French Lake a peculiar augite-diorite occurs composed of quartz, plagioclase and augite; the areas of this rock, connected by transitions with normal types, are distinguished by the brilliant white color of the glaciated outcrops.

Diabase.—An area of diabasic rock occupies the eastern margin of the map, adjoined on the west by dark basic diorite. It is sometimes, as at Meadow Lake dam, rather a uralitized

* Compare: Petrographical notes from Baja California; W. Lindgren. Proc. Calif. Acad. Sci., 2d series, vol. i, Part II, 1888.

† It is also closely related to the Tonalite of Mount Adamello, but it did not for several reasons seem advisable to adopt that name.

diabase-porphyrite; at Fordyce dam, farther south, it is a biotite-diabase. The relations of the diabase to the granodiorite are not clear beyond doubt, but the latter appears to be the younger rock.

Andesite.—Several small masses of andesitic breccia of late Tertiary age cover the older rocks to the west of Meadow Lake; north and east of it large masses of this volcanic rock appear.

Ore deposits.—The granodiorite area contains between Signal Peak and Meadow Lake a great number of black veins and seams composed of quartz, tourmaline and epidote, together with grains and smaller masses of pyrite. In certain places the latter mineral, and other sulphides have been formed to a large extent and are auriferous enough to render their exploitation possible. A few of the veins which have been worked from time to time are indicated on the figure. The strike is northerly or northwesterly, the dip vertical or at high angles to the northeast; the width of the veins is variable; sometimes, as at Excelsior, it reaches twelve feet. The walls are frequently indistinct. The veins near Meadow Lake do not seem to be traceable for long distances, while some of those of Old Man Mountain, which is a rounded granitic dome, traversed in several directions by fissure systems, appear to be continuous for half a mile or more. The country rock is not extensively altered in the vicinity of the veins. Many small veins occur at the contact of granodiorite and diabase near Meadow Lake and a few are also found in the latter rock just south of the lake.

Meadow Lake and vicinity,
Scale 2 Miles = 1 Inch.

Ores.—The ores consist of iron pyrite, arsenical pyrite, pyrrhotite, zincblende, and rarely galena; on the decomposed surface much coarse free gold occurred which, however, was

soon replaced by the sulphides mentioned and in which the gold occurs in extremely fine distribution.

Auriferous copper ores prevail at the Keystone, with cuprite, chrysocolla and other secondary minerals. At the most developed mine, Excelsior, iron pyrite is the most abundant ore. Silver does not occur to any notable extent in the ores.

Gangue.—While some white quartz with admixed sulphides occur, the usual gangue is a black, hard and dense rock of sometimes almost basaltic appearance, in which the ores are disseminated.* In more coarse-grained specimens yellow epidote, quartz grains and small radiating aggregates of a dark brown tourmaline are visible. Under the microscope the black veinstone is resolved into an interlocking aggregate of quartz grains, occasionally traversed by cracks along which comminution and crushing has taken place; gas and fluid inclusions are plentiful; epidote and sometimes zoisite form aggregates in places; tourmaline occurs as irregular grains with the quartz but much more commonly as slender crystals and radial aggregates intimately and plentifully imbedded in the quartz. The tourmaline has pleochroic colors varying from bright brown to dark bluish or greenish gray. Skeleton crystals are common, the interior being filled with quartz grains and bunches of radial chlorite. This latter mineral is quite common in some slides, sometimes traversing the tourmaline in small veins. Brown mica occurs in aggregates, together with the tourmaline. A colorless mica, titanite, ilmenite and some calcite were also observed. The ores occur intimately intergrown with this gangue. In one case pyrite was observed surrounded by a ring of pyrrhotite.

In a small vein occurring where the trail to Meadow Lake crosses Fordyce creek grains of a faintly greenish monoclinic pyroxene and probably also a little albite occur together with abundant quartz, tourmaline, epidote and pyrite. The occurrence of pyroxene in veins of this class is certainly not usual. Pyroxene is however not exclusively an igneous mineral; Daubrée has long ago shown that it may be formed by the action of superheated water on glass containing iron, and according to Brögger† it sometimes occurs in the veins of the syenite of southern Norway together with zeolites and calcite in such a way that it must be regarded as having been formed contemporaneously or even later than the zeolites.

* Mr. Alfred R. Conkling, who for some time was engaged as a geologist of the Wheeler Survey, makes indeed the startling statement that "the ore deposits at Meadow Lake are generally found in a mass of basalt enclosed in the country rock, gray granite." Annual Report of Chief Engineer, 1878, Appendix NN, p. 183.

† Zeitschr. Kryst. u Min., xvi, p. 329.

From the data given above it appears probable that the larger part of contents of the veins should be regarded as country rock intensely altered by solutions containing heavy metals and boron, ascending along narrow cracks and fissures.

Somewhat similar deposits have recently been described by W. Moericke from Chile.* In these occurrences a hornblende-biotite-granite of probably Tertiary age is in the vicinity of the veins altered to a tourmaline rock nearly identical with that here described; the veins proper occur in this tourmaline rock and consist of quartz with but little tourmaline, together with auriferous copper ores.

Washington, D. C., April, 1893.

Art. XXXI.—*The Stability of Standard Solutions of Tartar Emetic;* by Hippolyte Gruener.

[Contributions from the Kent Chemical Laboratory of Yale College—XXVI.]

During the progress of some investigations on antimony, I found it desirable to know to what extent a solution of tartar emetic could be relied on to retain its strength when kept for a length of time. Accordingly I made up a number of solutions of tartar emetic, whose strength was determined by titration in presence of an alkaline tartrate and bicarbonate with decinormal iodine, standardized against arsenious oxide. These solutions were put aside in stoppered bottles for a number of months, when they were again determined with iodine standardized against the same arsenious oxide.

Solution A was simply tartar emetic in distilled water, 16 grms. to the liter. At the end of five months this was found to have lost strength to a considerable extent, while a deposit, seemingly a mixture of antimonious oxide and of fungus growth had settled at the bottom of the bottle. At the end of fourteen months a still greater loss of strength was observed, corresponding in all to about 3·5 per cent of the tartar emetic, of which 4 grms. were present. The sediment was drained, dissolved in tartaric acid and titrated with iodine. It was found to correspond to ·13 grm. of tartar emetic or approximately the amount lost. This shows clearly that under the conditions no great loss is caused by the formation of the pentoxide, in closed bottles at least.

Solution B was slightly alkaline with sodium bicarbonate in presence of sodium tartrate. On this solution after five months there was developed in addition to a fungus growth a

* Min. und Petr. Mitth., xii, No. 3.

deposit, probably antimonious oxide; there was here a slight loss in the strength of the solution, amounting to 1 per cent.

Solution C was acid with tartaric acid only. After ten months the solution was found of the same strength and clearness as it was originally: but four months later there was a slight deposit accompanied by a loss of 1·2 per cent.

Parallel experiments to A gave like results. Two repetitions of C with varying amounts of tartaric acid present showed in each case a decided fungus growth with no loss of strength at the end of five months, whereas at the end of nine months the loss amounted to 1 per cent for the larger amount of tartaric acid and 0·3 per cent for the smaller amount.

It seems then that there is little danger of any oxidation of the antimonious oxide occurring, and provided enough tartaric acid is present to keep all the antimonious oxide in solution, the solution should maintain its strength for at least five or six months. The fungus growth has not been found to interfere in practical work with the solutions, yet it seemed advisable to prevent its formation if it could be done simply. To test the possibility of this, a number of solutions were prepared containing varying amounts of hydrochloric acid, which should act as a sterilizer; enough tartaric acid was added to counteract any tendency toward precipitation. In one series of experiments the solutions were sterilized at the beginning by boiling; in the other series distilled water which had been exposed more or less to the air for a number of days was directly used. Where the solutions had been thus sterilized no sign of fungus growth had appeared at the end of five months, and in the case of the unsterilized solutions there was never more than a trace. Where the hydrochloric acid present was not more than 10 cm^3 to 500 cm^3 of water, there was at the end of three months only the faintest trace of a deposit and no material loss of strength. Where the hydrochloric acid was present to the extent of 25 cm^3 in 500 cm^3 of water a decided granular precipitate was observed, accompanied by a loss of strength of about 10 per cent. The granular precipitate dissolved in tartaric acid and titrated accounted almost exactly for this loss.

A number of solutions were prepared under varying conditions and left open to the air for three months, at the end of which time no loss from oxidation was found.

It may be seen that tartar emetic in a solution of 16 grms. to the liter is not oxidized either in closed or open bottles. If it is desired to keep this solution as a standard for a moderate length of time it can be done in presence of enough tartaric acid (20 to 30 grms. to the liter) to prevent precipitation. The addition of 1^{cm} hydrochloric acid to one liter of solution

is enough to prevent any decided formation of fungus growth, at the same time not enough to cause a deposit as happens when large amounts of hydrochloric acid are used.

In the titration of tartar emetic in presence of starch the permanent blue color was taken in every case as the indication of the end reaction, as all other shades of color were found unsatisfactory. It is a well known fact that in the titration of antimony salts the color of the starch iodide is not developed until there is a considerable excess of iodine present, so that as compared with arsenious oxide, iodine gives high results with antimony. Thus, for example, the mean of six series of determinations made at various times and aggregating twenty-nine determinations showed the presence of 43·95 per cent of antimonious oxide in tartar emetic. (Sb = 120 and tartar emetic $KSbOC_4H_4O_6 . \frac{1}{2}H_2O$. = 332, requiring 43·37 per cent.)

The facts above shown, that tartar emetic may be kept in stable solution by means of tartaric acid and hydrochloric acid in the proportions given, make it possible to use and keep such solutions for standardizing iodine for the determination of antimony, and thus to eliminate the error due to the tardy development of the starch iodide blue in presence of antimony salts, observed when compared arsenious oxide is used as a standard.

ART. XXXII.—*Description of Rowlandite;* by W. E. HIDDEN and W. F. HILLEBRAND.

I. *Historical and Descriptive Discussion, by W. E. Hidden.*

ABOUT one kilogram of the mineral described in this paper was found by the writer in rather large lumps among huge masses of gadolinite and yttrialite, in a single shipment of the various yttria-bearing minerals, sent to him some five years ago, from the noted locality in Llano County, Texas.

The alteration products attracted my attention at once by their dissimilarity to those of gadolinite, yttrialite and allanite from the same mine. Several preliminary trials proved the mineral to contain over sixty-one per cent of the "rare earths" having a joint atomic weight of 118·5. The ignited oxalates had a pale straw color and the absorption spectrum of a saturated nitrate solution showed the lines of the erbium and didymium groups very prominent. Ferrous-oxide was found to be present (in one instance estimated at 4·69 per cent) and by the use of ammonium carbonate 0·40 per cent of what appeared to be uranium oxide was separated from the iron

solution. Three determinations of silica gave 25·98 per cent, 26·46 per cent and 25·64 per cent. A small amount of lime was also found. The loss on ignition was 2·01 per cent, but this was then considered as wholly due to hydroxyl and that fluorine was present was not even suspected. The apparent shortage, of nearly 5 per cent, was thought to be due to alkalies, magnesia and other non-essential elements and also to the fact of the hurried character of these preliminary analyses. That the mineral was essentially unlike gadolinite and could not be considered as a non-thoriferous yttrialite seemed proven and so it was laid aside until it could be looked into thoroughly.

Prof. Rowland photographed the spectrum of this mineral and also the "earths" from its oxalates and found them to be not essentially different from those of gadolinite and other minerals rich in yttria. He, however, expressed the opinion that there were at least *a dozen unknown elements* in the so-called yttria group not yet separated. The scale on which he showed its spectrum represented a length of ten feet and over *ten thousand* lines were noticed.

Later, the density was determined as 4·515, on carefully selected fragments. Its color varies from bottle- to pale drab-green when pure and its luster on a fractured surface is decidedly more vitreous than that of gadolinite. It is also more transparent, being perfectly so, in thin splinters. Its alteration product is of a waxy-brick-red color tending towards brown and this is peculiarly characteristic. The alteration has been one of further oxidation of the iron, hydration and partial change to carbonates.

The mineral is isotropic, its hardness is 6, its fracture glassy-conchoidal, its luster vitreous-resinous and the powdered mineral is light greenish gray. It is easily soluble in acids with gelatinization. Before the blowpipe it swells up without appreciable glowing but when strongly heated it emits a brilliant light without fusing. Any change of density was not investigated. The above data warranted me in calling the mineral new and quite distinct from gadolinite with which it is found associated. I proposed therefore, in a note published in this Journal in November, 1891, "the name of *Rowlandite* after Professor Henry A. Rowland, whose spectrographic work on the so-called 'rare earths' is so novel and important."

Through the kindness of Prof. F. W. Clarke, of the U. S. Geol. Survey, it has been possible to complete the description of this new mineral with the analysis and discussion of its composition by Dr. W. F. Hillebrand, given in the following pages.

II. *Analysis and Discussion of composition, by W. F. Hillebrand.*

The specimen of rowlandite, furnished by Mr. Hidden for analysis, was a portion of a mass resembling somewhat amorphous gadolinite. It had a glassy interior surrounded by an uneven thickness of reddish alteration substance, chiefly a carbonate, or carbonates, of the rare earths and lime. The glassy "rowlandite" showed, when broken up, reddish and dark stains in places, the latter being produced by minute black inclusions, perhaps of a titanium mineral. Numerous scarcely visible fissures, filled with foreign matter, traversed the glass. This rendered the selection of pure material an arduous task; the result of several days of labor, however, was a sample possessing a high degree of purity as shown by the microscope. A very small amount of impurity was still present, but much less, apparently, than the analysis seems to indicate. A slight cloudiness in some grains points to incipient change. Its density is the same as that found by Mr. Hidden, 4·513, at 15·5° C. The analysis is as follows:

			Mean.	
SiO_2	25·77	26·04	26·04*	
X†	·39		·39	
ThO_2	·59		·59	
Ce_2O_3‡	5·06		5·06	
La group	9·34		9·34	Mol. Wt. 336·8
Yt group	47·70		47·70	Mol. Wt. 266·2
Fe_2O_3	·09		·09	
FeO	4·39§		4·39	
MnO	·70	·64	·67	
CaO	·60	·40	·50	
MgO	1·58	1·66	1·62	
Alk	·32	·24	·28	
H_2O	·24		·24	
CO_2	·34		·34	
Fl	3·87		3·87	
P_2O_5	trace		trace	
			101·12	
	Less O for Fl,		1·63	
			99·49	

* Certainly more nearly correct than 25·77, since the fluorine must have caused loss of silica on evaporation with hydrochloric acid.

† A mixture of undefinable earths with some uranium and a trace of titanium.

‡ Cerium dioxide cannot be present, if at all, in more than trivial amount, for otherwise much less ferrous oxide would have been found. For the same reason the manganese cannot be present as Mn_2O_3.

§ If the small and undetermined amount of uranium exists as dioxide, the ferrous oxide here given is correspondingly high, but the possible error can have no influence on the formula deduced.

In calculating the molecular ratios a brief consideration shows that CaO and CO_2 may be neglected, and likewise, so far as their effect on the general formula is concerned, the ThO_2 and the group denominated X; also the trace of ferric oxide and the alkalies. For the present the water may also be disregarded. There result then the following molecular ratios:

SiO_2	26·04	÷ 60 =	·4340		3·91
Ce_2O_3	5·06	328·4	·0154	·2223	2·00
La group	9·34	336·8	·0277		
Y group	47·70	266·2	·1792		
FeO	4·39	72	·0610	·1109	1·00
MnO	·67	71	·0094		
MgO	1·62	40	·0405		
Fl	3·87	19	·2037		1·84

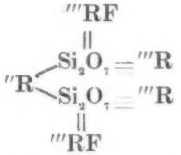
These furnish the following empirical formula, after deducting 10 atoms of oxygen for 20 of fluorine:

$$Si_{43}'''R_{44}''R_{11}F_{20}O_{154}$$

The silica is in all probability as much as half a per cent too low through loss occasioned by the presence of fluorine. Furthermore, it is possible that the fluorine, estimated by the Berzelian method, is a little too low; or, if not, that the small amount of water found is in part at least derived from hydroxyl replacing fluorine. The presumption is then strong that the composition of rowlandite is represented by the formula

$$Si_{44}'''R_{44}''R_{11}F_{42}O_{154}, \text{ or in simplified form } Si_4'''R_4''RF_2O_{14}$$

Structurally this formula may perhaps be written in a number of ways, that which most readily suggests itself being



in which the mineral is to be regarded as a derivative of the acid $H_6Si_2O_7$. Until, however, the whole group of rare earth silicates is carefully studied and their relations among themselves and to other better known silicates are ascertained, it would be premature to pronounce in favor of this or any other structural formula.

Reducing all the other earths to a hypothetical one having the molecular weight of the yttrium group as found, and the manganese and magnesia to their equivalents in iron, the com-

position of an ideal rowlandite would appear as in the first column below, while the second column shows the percentages required to conform to the above formula.

	Found.	Calculated for $Si_4Y_4FeFl_2O_{14}$.
Si	12·73	12·93
Y	50·83	50·37
Fe	6·50	6·46
Fl	4·05	4·39
O	25·89	25·85
	100·00	100·00

The agreement is very close and becomes much more so if the suggested slight increase in silica and fluorine is allowed.

ART. XXXIII.—*The Upper Hamilton and Portage Stages of Central and Eastern New York;* by CHARLES S. PROSSER.

THE correlation of the Upper Devonian rocks of central and eastern New York has for a long time been a question of great difficulty and several interesting statements have recently been published in reference to this problem. The region is one familiar to me, and while recognizing the generally accurate description of the geologic sequence of this mass of rocks, the correlation and consequent age of a portion of the terranes under consideration, included between the base of the Oneonta sandstone and the top of the Hamilton stage, seem to call for a brief explanation of their paleontology and stratigraphy. This region was somewhat briefly described by Dr. H. S. Williams in a paper on "The classification of the Upper Devonian"* in 1885; in addition to this a large amount of data has been accumulated in reference to the paleontology and stratigraphy of the region, the greater part of which is in the hands of Dr. Williams for use in the preparation of a monograph describing the Devonian system of the United States.

The term "Oneonta group" has been used for two entirely different geologic terranes in the same region of New York, hence it would seem advisable to review the history of the use of the names under consideration.

The Oneonta sandstone was defined by Vanuxem in 1840, as follows: "*Montrose sandstone*, or sandstone of Oneonta; this is the last or upper rock of the third district [third geological

* Proc. Am. Assoc. Adv. Sci., vol. xxxiv, p. 225. See in particular Sections No. VIII, IX, X on the chart of meridional sections accompanying the paper.

district of New York]; it consists of many veins of gray sandstone, and sometimes of red sandstone . . . . this rock is found in Otsego, Chenango and Broome counties [New York]; it covers the whole of the upper part of Susquehannah county, in Pennsylvania, and being there an abundant rock and surrounding the town of Montrose, I have thought it well to apply its name to this rock."* This description classed as one formation the Oneonta sandstone, which in that region is overlaid by rocks containing at the base a Portage fauna, higher Chemung species and finally is capped by the Catskill stage, the united mass of these terranes forming Vanuxem's Montrose or Oneonta sandstone. In the same year, Professor Mather proposed the "Catskill Mountain series" and described it as "that [series] which lies between the Helderberg limestone series and the coal-bearing rocks of Carbondale in Pennsylvania."† In his following report Professor Mather subdivides this series into eight groups as follows:

"1. Conglomerates and grits.
2. Red and gray grits with red shales mottled with green spots.
   Montrose sandstone of Professor Vanuxem.
3. Chemung group of Professor Vanuxem.
4. Ithaca " " " "
5. Sherburne flags " " "
6. ———————
7. Hamilton group " " "
8. Marcellus shales " " " "‡

Vanuxem in his final report classed together the "Montrose and Oneonta Sandstone of the Reports" and called them the "Catskill group;" which he regarded as equivalent to the "Old Red sandstone of England."§

In 1841 Conrad published a classification of the rocks of New York. The "formations" were numbered in ascending scale and the following were referred by him to the "Upper Silurian Series":

"26. Oneonta group.
25. Cazenovia "
24. Tully limestone.
23. Sherburne group.
22. Shales near Apulia.
21. Black slate." ‖

* 4th Ann. Rep. Third Geol. Dist. N. Y., p. 381.
† 4th Ann. Rep. First Geol. Dist. N. Y., p. 227.
‡ 5th Ann. Rep. First Geol. Dist. N. Y., p. 77.
§ Geol. N. Y., Pt III, 1842, p. 186.
‖ 5th Ann. Rep. Palæontology N. Y., p. 31.

There is one mistake in reference to the stratigraphic order of the groups of the above list. The "Cazenovia group" belongs *below* instead of above the Tully limestone. This error was corrected by Vanuxem in his final report, where under the heading of the Hamilton, the "Cazenovia group" is given as one of its divisions.*

To one who is not familiar with the geological outcrops near Cazenovia, a glance at the geological map of New York of 1843, or the one showing the "Geographical distribution of the Tully limestone in central New York" by Professor S. G. Williams,† will show the exposures of Tully limestone as considerably south of Cazenovia. Of course the "Black slate" represents the Marcellus shale, while the "shales near Apulia," and the "Sherburne group" are parts of the Hamilton stage as stated by Vanuxem.‡ It is interesting to note that the term "Sherburne group" of Conrad is not the same as the "Sherburne flagstone and shale" of Vanuxem as will be seen from an attentive examination of his final report.§ The Sherburne flagstones of Vanuxem are a mass of sandstones in the Chenango Valley above the horizon of the Tully limestone, which are mostly non-fossiliferous and are synchronous with the lower part of the Portage as exposed farther west. Below these flagstones are argillaceous shales which contain an abundance of Hamilton fossils, as for instance in the shales at Rexford or Sherburne falls. The same zone is well exposed in the gorges near Smyrna where the Sherburne flagstones form the top of the high hills, and most of the species which Conrad gave as belonging to the "Sherburne group" were from "near Smyrna." The following, which are now all well known Hamilton species, were named and described:

Nuculites oblongatus, *N. rostellatus*, *N. bellistriatus* [now *Nucula bellistriata*], *Orthonota undulata*, *Cypricardites oblonga* [now regarded as a synonym of *Modiomorpha concentrica* (Con.) Hall], and *C. rugosa* [now *Goniophora rugosa* (Con.) Miller].‖

Above this zone Conrad placed the Tully limestone, but apparently no representative of the Genesee shale is given. The highest rocks are the Oneonta group which are supposed to have been named from exposures near that town. *Nuculites cuneiformis*, *N. maxima* [now *Palæoneilo maxima* (Con.) Hall], and *Cypricardites carinata* [now *Goniophora carinata* (Con.) Hall] were named and described from this formation at

* Geol. N. Y., Pt. III, p. 150.

† Sixth Ann. Rep. State Geologist [N. Y.] for 1886; map following p. 28.

‡ Geol. N. Y., Pt. III, p. 150.

§ See the explanation of the names that had been used for different parts of the Hamilton on p. 150, and the same for the Portage on p. 172.

‖ 5th Ann. Rep. Palæontology N. Y., pp. 50–54.

Oneonta. The shales and sandstones which contain these fossils are exposed at the base of the high hill near Oneonta, and are *below* the reds and grays which compose the terrane to which Vanuxem gave the name Oneonta sandstone. The quarry, a short distance west of Oneonta and below the highway, contains these species in association with others, especially *Paracyclas lirata* (Con.) Hall, *Chonetes scitula* Hall and *Tropidoleptus carinatus* (Con.) Hall. Above the highway fossils become rare and gradually disappear, the last species noted being *Nuculites cuneiformis* Con. and *Palæoneilo maxima* (Con.) Hall, about half way up the hill. It seems that Conrad's name for this zone was not considered in the final reports of the New York Survey, although Vanuxem referred to the horizon in several places; for instance in describing the hill near Oneonta, mentioned above, it is stated that the Catskill group or Oneonta sandstones of Vanuxem "occupy the highest part of the face of the hill, the base of which is composed of rocks which I [Vanuxem] have supposed to belong to the Ithaca group."*

So far as the writer is aware he first called attention to the twofold use of the term "Oneonta group," and indicated the stratigraphic place of each zone.† The zone is well exposed in the Susquehanna, Unadilla, and Chenango river valleys, especially at Oneonta, Oxford and Norwich. In reference to the correlation of the deposits below the Oneonta sandstone there seem to be many conflicting opinions, owing to the fact of the absence of the Tully limestone and the Genesee shales in central and eastern New York. It is true that their distinctive lithologic characters simplify the matter of separating the Hamilton from the overlying Portage in all that area where they are present. But the writer found that a careful study of the facies of the fauna of each zone, supplemented by actual observation of their stratigraphic position and relation in the field, enabled him to separate the fauna of the typical Hamilton from those of the modified Hamilton faunas of the overlying rocks in regions where there was no trace of the Tully limestone or Genesee shale.

This method of separating the Hamilton from the Portage above was thoroughly tested during the summers of 1890–91 in an examination of the Devonian system along the eastern face of the Catskill mountains from Greene county, New York, to Carbon county in eastern Pennsylvania. It was noted that although the fossils in the upper rocks were mostly species found in the typical Hamilton of central and western New York, still there were slight variations or even varietal modifi-

* Geol. N. Y., Pt. III, p. 192.
† Proc. Am. Assoc. Adv. Sci., vol. xxxvi, 1887, p. 210.

cations which when observed, enabled one to separate them. There are frequently lithologic variations to assist, as in eastern Pennsylvania, which were used to advantage in the work of Prof. I. C. White for the 2d Geological Survey of that State, and a knowledge of these *two* characters was found necessary for the correlation of the Upper Devonian of this region. This principle was tested several times by different observers and it was found that those paleontologists who had simply studied the species in a general way without considering the minor variations due to the difference in geographic distribution or stratigraphic range did not recognize the different facies of these faunas but called them all Hamilton; while two paleontologists who had closely studied the characters of the faunas and had also noted similar comparatively slight changes in reference to the distribution and range of species for another region, on being shown collections of these fossils without any information as to their stratigraphic position, invariably recognized those that came from the beds corresponding to the typical Hamilton of New York, as well as the slightly modified faunas from the overlying rocks. And this recalls the principle stated by Dr. H. S. Williams when describing the classification of the Upper Devonian for southern and western New York, viz:—"the complications arising from both geological and geographical modifications of fossil faunas are so great that the attempt to determine horizons by single or by roughly identified fossils will certainly lead to erroneous results."* The failure on the part of paleontologists to observe this rule and the tendency on the part of the stratigraphic geologists to base their correlations mainly on lithologic characters have continually made futile all attempts toward an accurate correlation of the terranes of the Upper Devonian for southern and eastern New York, and eastern Pennsylvania.

In a recent article is the statement that "the basal beds [of the Oneonta formation] are gray flags which merge into the Hamilton;"† but no data is given in favor of such correlation and I suppose the opinions of other geologists were followed.

This particular part of the series is one to which the writer of this paper has given especial attention, not only so far as the fossils from the different regions and horizons are concerned but he has also made cross sections at various points from

* Proc. Am Assoc. Adv. Sci., vol. xxxiv, 1886, p. 231.

† The stratigraphical relations of the Oneonta and Chemung formations in eastern Central New York; by N. H. Darton. This Journal, III, vol. xlv, p. 206. In addition see on p. 207 the statement that the Hamilton is exposed at Lyon Creek bridge, near Oxford; also, that "The Chemung rocks to which Mather and others refer lies below the Oneonta beds or about 1,000 feet below the actual base of the Chemung horizon, and are Hamilton in position. This fauna is meagre and consists of species supposed by Vanuxem to be Chemung in central New York, but now known to be Hamilton."

central New York to central Pennsylvania and traced the continuation of the different zones, so that he feels inclined to speak with considerable positiveness in reference to this portion of the New York Upper Devonian. Moreover, since a new geologic map of New York is in process of coloration, it seems that attention should be called to the correlation of this particular part of the series. Indeed, most of the statements that have been made during the last ten years as to the age of these rocks are not so accurate as the conclusions of Vanuxem over fifty years ago; so that if this area be colored on the new map, as one would infer from these occasional statements, the map for that section of the State will not be so accurate as the one of 1843. These remarks apply especially to that part of the geologic column which in western central New York extends from the Genesee shale to the base of the Chemung, while for central and eastern New York and Pennsylvania from the Marcellus shale to above the lower reds and grays, called the Oneonta sandstone, as high as marine fossils have been found.

Our reason for differing from the ordinary statements in reference to the age of the rocks immediately underlying the Oneonta sandstones (which compose the Oneonta group of Conrad) will be much more clearly understood if we consider first a section like that of Cayuga lake, where the Tully limestone and Genesee shale are present in their full development, and consequently where there can be no question as to the upper limit of the Hamilton stage as originally defined and generally understood and accepted. The bluffs along Cayuga lake and the exposures south of Ithaca, which have been carefully studied and fully described by Dr. H. S. Williams in various publications, afford such a section.* Along the shores of Cayuga lake are exposed 1,000 feet of argillaceous shales and sandstones containing an abundant and typical Hamilton fauna. Capping the Hamilton is the Tully limestone varying from 15 to rather more than 20 feet in thickness. This is overlaid by the Genesee shale, a very fissile, black, argillaceous shale 100 feet in thickness in this region which in some of the glens, as Burdick's, is capped by a prominent sandstone nearly four feet in thickness. The sandstone marks the beginning of the Portage, the lower division of which is composed of sandstone and shales containing but few fossils with a thickness of 250 feet.† Succeeding this division is the "Ithaca group" of Vanuxem, or the middle Portage of Professor Williams, with a thickness of

*See particularly Bull. U. S. Geol. Survey, No 3, 1884; also Science, vol. i, old series, Oct. 16, 1880, p. 190, Proc. Am. Assoc. Adv. Sci., vol. xxx, p. 1, of reprint, and ibid., vol. xxxiv, p. 222.

†This part constitutes the entire Portage of the Cayuga lake region as described by Professors Hall and Vanuxem in their final reports. See Geol. N. Y., Pt. IV, p. 250, and ibid., Pt. III, p. 174.

450 feet. Portions of this division contain abundant fossils and the fauna is made up of an assemblage of Hamilton, Portage of western New York and a few species which are found in the Chemung, together with those that are peculiar to the Ithaca zone. Following the "Ithaca group" are 600* feet of shales containing only a few fossils which are mainly the same as those of the Lower Portage. Professor Williams, who first noticed and described this zone, called it the Upper Portage and consequently assigned to the entire Portage of the Cayuga lake region, a thickness of 1300 feet. Succeeding these barren shales and sandstones are shales of different lithologic character which contain the regular Chemung fauna as known somewhat farther south in the typical locality near Chemung, and possibly now with better exposures near Waverly. In this section there has never been any question as to the upper limit of the Hamilton, and no one has proposed to call the rocks of the "Ithaca group" with a modified Hamilton fauna, a part of the Hamilton stage. The Ithaca fauna was correlated differently by Vanuxem who called it "a group between the Portage and Chemung," and by Professor Hall who considers it the lower part of the Chemung stage; but both of these geologists overlooked the non-fossiliferous zone above, which was observed by Professor Williams, who has classified the rocks of this section in a perfectly satisfactory manner.

Now if we consider the section of central New York along the Chenango valley, we shall find a decided change in the order of the stratigraphic character of the section, although certain zones or stages may be and have been traced continuously by several geologists from Cayuga lake into the Chenango valley. The Tully limestone and Genesee shale are two stages which have been followed to a locality near Smyrna village in the northern part of Chenango county. To be sure they are much less in thickness than where exposed on Cayuga lake, still there is no question that they represent the same geologic horizon, as has been attested by every observer who has gone over this field. It was so understood by Vanuxem, in 1842;† more definitely described by Prosser in 1887;‡ the Tully limestone mapped with this eastern exten-

* For the thickness of these divisions of the Portage see Prosser in Trans. Am. Inst. Min. Eng., vol xvi, p. 945; also for the thickness of the Upper Portage see this Journal, III, vol. xxxii, p. 198, where Professor Williams says: "The fossiliferous zone at Ithaca is separated from the lowest beds containing characteristic Chemung fossils by about 600 feet of nearly barren, flaggy and shaly deposits, but with a few fossils which belong to the characteristic Portage fauna."

† Geol. N. Y., Pt. III, pp. 164, 169 and 292.

‡ Proc. Am. Assoc. Adv. Sci., vol. xxxvi, p. 210, where the thickness of the Genesee shale is given as 20 feet, and the limestone layers and calcareous shales as 25 feet, near Upperville in Smyrna township.

sion by Professor S. G. Williams in the same year,* and finally so indicated by Dr. H. S. Williams in 1890.†

The bearing of this horizon will be immediately appreciated when we remember that Smyrna is in the Chenango river valley, while Oxford is nineteen miles farther south in the same valley near which place it is stated the Hamilton is exposed. The fossiliferous zone near Oxford is well exposed at Norwich and on the hills near North Norwich, but farther north at Sherburne it is found only near the top of the high hills and at Smyrna it is hardly reached at the summit of the highest hills. Some of the species belong in the Portage and many occur in the Hamilton, among which are those slightly modified from the Hamilton forms. The recurrence of the Hamilton species in the higher beds has probably led several geologists to refer these rocks to the Hamilton stage, and to ignore the clear and perfectly conclusive stratigraphic evidence of their age. The most authoritative correlations of this zone with the upper part of the Hamilton stage are indicated in the following foot note.‡

The stratigraphic sequence and general correlation of the Hamilton and Portage stages for Chenango and Otsego counties were described by the writer in 1887;§ but at this time it

* Sixth An. Rep. State Geol. [N. Y.] for 1886, p. 13; and see map facing p. 28.

† Bull. Geol. Soc. Am., vol. i, p. 489.

‡ In the Geol. Surv. N. Y., Palæontology: vol. v, Pt. I, Lamellibranchiata II, 1885, several species are reported from localities in this zone which is called Hamilton; as *Goniophora carinata* (Con.) Hall, from Oneonta, p. 302; *Microdon (Cypricardella) complanatus* Hall, below Norwich, p. 312; *Nuculites cuneiformis* Con., at Oneonta, p. 326; *Palæoneilo arata* Hall, "shales of the Hamilton group, near Norwich," p. 342; *Prothyris planulata* Hall, near Norwich, p. 460; *P. lanceolata* Hall, Norwich, p. 461; *Phthonia nodicostata* Hall, near Oneonta, p. 474; and finally on p. 517 is the statement that the Oneonta sandstone "comes in at about the close of the Hamilton period, or more properly may be regarded as the result of changes which terminated the conditions of the Hamilton group," while on p. 518 the Upper Devonian of Otsego, Delaware, and Chenango counties is correlated as follows:

"Catskill group.
Chemung "
Oneonta { Portage group.
Hamilton (Upper).
Hamilton group."

A similar statement in reference to the age of these rocks occurs in *ibid.* Lamellibranchiata I, as *Leptodesma Rogersi* Hall is reported "in the shales of the Hamilton group at Norwich, Chenango county," p. 177. Finally, in 1886, Professor Hall made the following statement in reference to a section near Oxford: "The results of the most recent investigations have served to substantiate my previous published statements, and clearly show that the Oneonta sandstone rests upon well marked Hamilton strata, and is succeeded by strata carrying the fossils of the Chemung Group" (Fifth An. Rep State Geologist [New York] for 1885, p. 4). Also the section on p. 11 represents the lowest shales and sandstones as belonging to the "Hamilton group," and mentions *Spirifera mesastrialis, Paracyclas lirata,* and *Polœoneilo muta* from these beds.

§ The paper was read at the New York meeting of the Am. Assoc. Adv. Sci., and an abstract published in vol. xxxvi, p. 210.

seems important to indicate more of the data upon which this classification was based. The upper zone of the Hamilton stage as exposed in the creeks and railroad cuts near Earlville, Smyrna and Sherburne, which was called the "Sherburne group" by Conrad, is composed of moderately coarse arenaceous shales which alternate with more argillaceous and calcareous shales containing abundant fossils. Along Pleasant brook above and below the Ontario and Western railroad station, in the edge of Smyrna village, as well as farther up the brook toward Upperville, are excellent exposures of these shales. Various species are abundant and careful search would be rewarded by a large list of Hamilton fossils. A moderate search has afforded the writer the following species from along Pleasant brook and other exposures near Smyrna village, Chenango county.

1. *Ambocœlia umbonata* (Con.) Hall ..... (*aa*)*
2. *Spirifera fimbriata* (Con.) Hall..(*cc*)
3. *Tropidoleptus carinatus* (Con.) Hall ..... (*aa*)
4. *Chonetes coronata* (Con.) Hall...(*cc*)
5. *Chonetes deflecta* Hall (?).....(*r*)
6. *Chonetes setigera* Hall .....(*c*)
7. *Spirifera mucronata* (Con.) Bill..(*c*)
8. *Spirifera medialis* Hall .....(*rr*)
9. *Spirifera granulifera* Hall .....(*a*)
10. *Atrypa reticularis* (Linn.) Dal....(*r*)
11. *Athyris spiriferoides* (Eaton) Hall (*rr*)
12. *Orthis Vanuxemi* Hall .....(*rr*)
13. *Strophodonta perplana* (Con.) Hall (*rr*)
14. *Streptorhynchus chemungensis* (Con.) Hall .....(*r*)
15. *Cyrtina hamiltonensis* Hall.....(*rr*)
16. *Cryptonella planirostra* Hall....(*rr*)
17. *Chonetes scitula* Hall .....(*c*)
18. *Cimitaria recurva* (Con.) Hall...(*rr*)
19. *Paracyclas tenuis* Hall .....(*rr*)
20. *Palæoneilo emarginata* (Con.) Hall (*r*)
21. *Schizodus appressus* (Con.) Hall..(*rr*)
22. *Palæoneilo constricta* (Con.) Hall..(*rr*)
23. *Nuculites triqueter* Con .....(*c*)
24. *Nuculites oblongatus* Con .....(*rr*)
25. *Pholadella radiata* (Con.) Hall ...(*r*)
26. *Orthonota* (?) *parvula* Hall .....(*rr*)
27. *Prothyris lanceolata* Hall .....(*rr*)
28. *Macrodon hamiltoniæ* Hall.....(*r*)
29. *Leda diversa* Hall.....(*rr*)
30. *Nucula bellastriata* (Con.) Hall ..(*rr*)
31. *Microdon* (*Cypricardella*) *tenuistriatus* Hall .....(*rr*)
32. *Modiomorpha concentrica* (Con) Hall ..... (*rr*)
33. *Modiomorpha mytiloides* (Con.) Hall ..... (*r*)
34. *Goniophora hamiltonensis* Hall..(*rr*)
35. *Goniophora rugosa* (Con.) Hall..(*rr*)
36. *Grammysia arcuata* (Con.) Hall..(*r*)
37. *Modiomorpha subalata* (Con.) Hall ..... (*rr*)
38. *Leptodesma Rogersi* Hall (?) ....(*rr*)
39. *Pterinopecten Vertumnus* Hall....(*c*)
40. *Cypricardinia indenta* (Con.) Hall (*r*)
41. *Modiella pygmæa* (Con.) Hall....(*rr*)
42. *Microdon* (*Cypricardella*) *bellistriatus* (Con.) Hall .....(*rr*)
43. *Grammysia constricta* Hall.....(*rr*)
44. *Nucula lirata* (Con.) Hall.....(*rr*)
45. *Orthonota carinata* Con. .....(*rr*)
46. *Leda rostellata* (Con.) Hall.....(*rr*)
47. *Palæoneilo muta* Hall.....(*rr*)
48. *Phthonia cylindrica* Hall .....(*rr*)
49. *Mytilarca* (*Plethomytilus*) *oviformis* (Con.) Hall.....(*r*)
50. *Tellinopsis subemarginata* (Con.) Hall ..... (*rr*)
51. *Pterinea flabella* (Con) Hall ....(*rr*)
52. *Cimitaria elongata* (Con.) Hall..(*rr*)
53. *Phthonia sectifrous* (Con.) Hall..(*rr*)
54. *Glytodesma erectum* (Con.) Hall..(*rr*)
55. *Nucula corbuliformis* Hall.....(*rr*)
56. *Phacops rana* (Green) Hall.....(*c*)
57. *Dalmanites Boothi* (Green) Hall..(*rr*)
58. *Homalonotus DeKayi* (Green) Emmons .....(*rr*)
59. *Platyceras carinatum* Hall .....(*rr*)
60. *Pleurotomaria capillaria* Con. ...(*r*)
61. *Coleolus tenuicinctum* Hall.....(*rr*)
62. *Bellerophon crenistria* Hall .....(*rr*)
63. *Bellerophon Leda* Hall .....(*rr*)
64. *Nucleospira concinna* Hall.....(*rr*)
65. *Chonetes mucronata* Hall .....(*rr*)
66. *Leiorhynchus multicosta* Hall ...(*rr*)

* The relative abundance of the species is indicated as follows:—*aa* = very abundant, *a* = abundant, *cc* = very common, *c* = common, *rr* = very rare, *r* = rare.

On the upper part of Pleasant brook between five and six miles from Smyrna village is an exposure of Tully limestone which is probably the one mentioned by Vanuxem.* The exposure is by the side of the brook, just above the highway bridge, where 26 inches of limestone are exposed with a blue argillaceous shale below, which contains plenty of fossils. The following species were obtained from this shale:—

1. *Spirifera mucronata* (Con.) Bill..(*a*)
2. *Vitulina pustulosa* Hall .....(*a*)
3. *Tropidoleptus carinatus* (Con.) Hall .....(*r*)
4. *Modiella pygmæa* (Con.) Hall...(*rr*)
5. *Nuculites oblongatus* Con.....(*rr*)
6. *Orthonota undulata* Con. .....(*rr*)
7. *Palæoneilo emarginata* (Con.) Hall .....(*rr*)
8. *Dalmanites Boothi* (Green) Hall. (*r*)

About one-half mile farther up the brook is an exposure of black, argillaceous, fissile shale, fifteen feet in thickness, in which an excavation has been made in search of coal. No fossils were found in the black shales, which are succeeded by rather thin sandstones.

There is a moderately steep hill west of Smyrna village and Pleasant brook, which is mostly covered above the gorge, though there are occasional exposures. In the highway near the top of the hill, in a small run, are smooth blue shales which are non-fossiliferous. In the field near the summit of the hill, about one mile west of Smyrna and from 475′–500′ above the R. R., is a small excavation that was made in searching for flagging stones. The rock is a coarse arenaceous shale, not as blue as the lower exposure, and contains a few fossils.

The following species were obtained:

1. *Spirifera mesacostalis* Hall .....(*c*)
2. *Spirifera fimbriata* (Con.) Bill.(?) (*r*)
3. *Cyrtina hamiltonensis* Hall .....(*c*)
4. *Leiorhynchus mesocostalis* Hall (*c*)
5. *Productella* cf. *speciosa* Hall ....(*r*)
6. *Atrypa reticularis* (Lin.) Dalman (*rr*)
7. *Chonetes setigera* Hall.....(*rr*)
8. *Ambocœlia umbonata* (Con.) Hall .....(*r*)
9. *Phacops rana* (Green) Hall.....(*rr*)

Below Upperville a small run, on the western side of Pleasant brook, gives a section from the fossiliferous Hamilton shales up through the Tully limestone and Genesee black shales into the overlying barren Portage. The shales in the lower part of the run contain specimens of

*See Geol. N. Y., Pt. III, 1842, p. 164, where Vanuxem says under "localities where observed.—The first point going west is on the turnpike from Sherburne to DeRuyter, about eight miles from the former village." Also under the geological description of Chenango county it is stated:—"The *Tully* limestone was seen but in one locality at the north western part of Smyrna, on the road to DeRuyter village where the road crosses the west branch of the Chenango," *ibid.*, p. 292. This outcrop was considered by Prof. S. G. Williams as the one described by Vanuxem (Sixth An. Rep. State Geologist [N. Y.], 1886, p. 18).

1. *Tropidoleptus carinatus* (Con.) Hall ..... (*a*)
2. *Spirifera mucronata* (Con.) Bill. (*rr*)
3. *Leiorhynchus multicosta* Hall ... (*r*)
4. *Orthis Vanuxemi* Hall ..... (*rr*)
5. *Palæoneilo emarginata* Con. .... (*rr*)
6. *Nucula lirata* (Con.) Hall (?) .... (*rr*)
7. *Phacops rana* (Green) Hall ..... (*rr*)

Above this zone about twenty-five feet of rather sandy limestone alternating with shales are exposed, and above the limestone twenty feet of black, fissile shale in which no fossils were found. Overlying the black shale are thin, regular sandstone layers, one-fourth to one-half inch thick which at first alternate with blocky, blackish argillaceous shales. The sandstones gradually become thicker for some distance and then are overlaid by blue, smooth shales which weather to an olive color. Beyond Upperville, twenty-five feet above the highway along which the black shales are exposed, a small quarry has been opened in the sandstone in which an occasional fossil occurs. Some search revealed only the following forms:—

1. *Lunulicardium fragile* Hall ... (*rr*)
2. *Leiopteria* ——— *sp.* ..... (*rr*)
3. *Crinoid stems.*
   Leiorhynchus mesocostalis Hall (*rr*)

A single specimen of the last species was found, which was not surely in place in the quarry, but possibly came from higher up the hillside.

The section on the upper part of Pleasant brook and the one just described on the hillside below Upperville, taken in connection with the one up the hill west of Smyrna show a passage from blue, argillaceous shales containing an abundant Hamilton fauna, up through the impure Tully limestone, the black Genesee shale, a sandstone zone and another of blue shale into coarse arenaceous shales or thin sandstones containing a meagre fauna, the species of which are found in the Portage and Ithaca groups. It seems to me there is no question but that the section passes from the Moscow shale of the upper Hamilton through the Tully limestone and Genesee shale into the lower Portage.

At Sherburne there are not such clear sections of the transition deposits from the Hamilton to the Portage, as at Smyrna; but there are excellent exposures of the upper Hamilton as well as some of the moderately fossiliferous overlying Portage.

Along Mad brook east from Sherburne village for one mile to Harrisville, rising from about the R. R. level to an elevation of 240′ above, at the reservoir in Harrisville, are numerous and excellent exposures of blue argillaceous shales with some coarse blue arenaceous shales forming the upper portion of the Hamilton stage. A limited search in the shales along Mad brook yielded the following species:—

1. *Chonetes coronata* (Con.) Hall (*aa*)
2. *Chonetes setigera* Hall (*aa*)
3. *Chonetes lepida* Hall (*rr*)
4. *Spirifera mucronata* (Con.) Bill. (*aa*)
5. *Spirifera granulifera* Hall (*rr*)
6. *Spirifera fimbriata* (Con.) Hall (*rr*)
7. *Ambocœlia umbonata* (Con.) Hall (*r*)
8. *Athyris spiriferoides* (Eaton) Hall (*r*)
9. *Orthis Vanuxemi* Hall (*r*)
10. *Strophodonta perplana* (Con.) Hall (*r*)
11. *Strophodonta inequistriata* (Con.) Hall (*a*)
12. *Streptorhynchus chemungensis* (Con.) Hall (*r*)
13. *Tropidoleptus carinatus* (Con.) Hall (*c*)
14. *Spirifera tullia* Hall (*rr*)
15. *Chonetes mucronata* Hall (*rr*)
16. *Chonetes scitula* Hall (*rr*)
17. *Nuculites triqueter* Con. (*aa*)
18. *Nuculites oblongatus* Con. (*r*)
19. *Palæoneilo constricta* (Con.) Hall (*a*)
20. *Palæoneilo emarginata* (Con.) Hall (*r*)
21. *Palæoneilo muta* Hall (*r*)
22. *Nucula bellistriata* (Con.) Hall (*c*)
23. *Nucula corbuliformis* Hall (*r*)
24. *Nucula lirata* (Con.) Hall (*r*)
25. *Paracyclas tenuis* Hall (*rr*)
26. *Macrodon hamiltoniæ* Hall (*rr*)
27. *Modiella pygmæa* (Con.) Hall (*c*)
28. *Orthonota* (?) *parvula* Hall (*r*)
29. *Orthonota carinata* Con. (*r*)
30. *Orthonota undulata* Con. (*r*)
31. *Cimitaria elongata* (Con.) Hall (*r*)
32. *Pholadella radiata* (Con.) Hall (*aa*)
33. *Prothyris lanceolata* Hall (*rr*)
34. *Grammysia arcuata* (Con.) Hall (*c*)
35. *Modiomorpha mytiloides* (Con.) Hall (*rr*)
36. *Sphenotus solenoides* Hall (*rr*)
37. *Tellinopsis subemarginata* (Con.) Hall (*rr*)
38. *Cypricardinia indenta* (Con.) Hall (*rr*)
39. *Microdon* (*Cypricardella*) *bellistriatus* (Con.) Hall (*rr*)
40. *Glyptocardia speciosa* Hall (*rr*)
41. *Goniophora hamiltonensis* Hall (*r*)
42. *Mytilarca* (*Plethomytilus*) *oviformis* (Con.) Hall (*r*)
43. *Loxonema delphicola* Hall (*a*)
44. *Pleurotomaria capillaria* Con. (*r*)
45. *Bellerophon Leda* Hall (*r*)
46. *Bellerophon acutilira* Hall (*rr*)
47. *Coleolus tenuicinctum* Hall (*r*)
48. *Dalmanites Boothi* (Green) Hall (*c*)
49. *Phacops rana* (Green) Hall (*r*)
50. *Homalonotus De Kayi* (Green) Emmons (*rr*)

About one mile southeast of Sherburne village is a high hill near the foot of which, about seventy-five feet above the R. R. level or 1117′ A. T.,* are somewhat coarse arenaceous shales with a moderate number of fossils, principally of the large species, as *Spirifera granulifera* Hall and its usual associated species. The fauna is distinctively Hamilton and the shales are in the Hamilton stage. Then for a distance of 440′ the hill slope is covered and at an elevation of 515′ above R. R. level or 1557′ A. T., there is an outcrop of coarse arenaceous shales alternating with thin blue flagstones. This bed contains some fossils and the fauna is the same as that of the highest exposures on the hills near Smyrna. The blue argillaceous shale, black shale and limestone below this zone are not shown in this section, on account of the thick deposit of drift.

About three miles north of Sherburne is the Mulligan quarry, at the top of a high hill, which furnishes thin blue flagstones with coarse irregular shales above them, containing fossils similar to those near the top of the hill west of Smyrna and the one southeast of Sherburne. By the barometer, this exposure is from 424′ to 446′ above the R. R., or 1466′ to 1488′ A. T.

* The R. R. station at Sherburne is 1042′ A. T.

At North Norwich, five miles south of Sherburne the zone of blue argillaceous shales, with no fossils, is well exposed along Blue or Cold brook, about 76′ above R. R. level or approximately 1099′ A. T.* At about 144′ above R. R. or approximately 1167′ A. T., is the base of the zone containing fossils. This zone is well exposed in the old Harris, now known as the Wilkes, quarry which was mentioned by Vanuxem† and is in the edge of Plymouth, about 305′ above R. R. level or approximately 1378′ A. T. Exposures near the top of the hill 427′ above the R. R. or approximately 1456′ A. T., still contain the same fauna.

In the Harris or Wilkes quarry the following species were found:

1. *Spirifera mesacostalis* Hall.....(*c*)
2. *Atrypa reticularis* (Linné) Dal. (*cc*)
3. *Leiorhynchus mesocostalis* Hall (*c*)
4. *Chonetes scitula* Hall (?) .....(*a*)

This species is abundant; but in the condition of impressions renders identification difficult. Some of the specimens approach *C. setigera* Hall in form, though they are not so convex near the umbo as those found at Ithaca.

5. *Chonetes lepida* Hall .....(*rr*)
6. *Cyrtina hamiltonensis* Hall ...(*rr*)
7. *Strophodonta sp.* ———, ...(*rr*)

Two imperfect impressions which are similar to *S. perplana* (Con.) Hall.

8. *Productella sp.* .....(*c*)
9. *Microdon* (*Cypricardella* (*bellistriata* (Con.) Hall or *M. tenuistriata* Hall .....(*rr*)

A single specimen which has the proportions of *M. bellistriata* as well as those of the elongated form of *M. tenuistriata* Hall (see Pl. 73, fig. 28). It is impossible to determine whether the specimen has the fine striae of *M. tenuistriata* or the coarse striae of *M. bellistriata*.

10. *Paracyclas lirata* (Con.) Hall..(*rr*)
11. *Cimitaria recurva* (Con.) Hall..(*r*)
12. *Palæoneilo emarginata* (Con.) Hall .....(*rr*)
13. *Goniophora carinata* (Con.) Hall (?) .....(*r*)

This species is reported from Copley's quarry at Oneonta.‡ A comparison of specimens from the two localities fails to prove them precisely similar; but the North Norwich specimens are nearer this species than any of the others figured in this work.

14. *Modiomorpha sp.* (a broken specimen) .....(*rr*)
15. (*?*) *Glossites depressus* Hall ....(*rr*)

A single specimen which apparently belongs to this genus and species.

16. *Palæoneilo constricta* (Con.) Hall .....(*rr*)
17. *Orthis sp.*.....(*rr*)
18. *Leptodesma* cf. *Rogersi* Hall ...(*r*)

These specimens do not have as mucronate ears as most of those figured; but some of them resemble closely the one figured on pl. 21, fig. 9 (Pal. N. Y., vol. v, Pt. I, Lamell. I), which is stated to be from the Hamilton shales at Norwich, N. Y.

19. *Streptorhynchus chemungensis* (Con.) Hall.....(*r*)
20. *Actinopteria Boydi* (Con.) Hall (*rr*)
21. *Phacops rana* (Green) Hall....(*rr*)

Of the seventeen species specifically identified in the above list, counting those that are questioned, there are twelve that occur in the "Ithaca group" at Ithaca. The general range of the other five species is as follows:

* The R. R. station at North Norwich is about 1023′ A. T.

† See Geol. N. Y., Pt. III, 1842, pp. 178, 293.

‡ Pal. N. Y., vol. v, Pt. I, Lamell. II, p. 302; see pl. 44, fig. 7 for figure of form similar to the North Norwich specimen.

Paracyclas lirata (Con.) Hall, common in the Hamilton of central and eastern New York, and then extends well up into the Portage; *Cimitaria recurva* (Con.) Hall, Hamilton of central New York and reported from Mt. Upton* which is near the same horizon as the Norwich and Oneonta zone; *Goniophora carinata* (Con.) Hall, from Oneonta and Mt. Upton and consequently in this zone; *Leptodesma Rogersi* Hall, in the upper Hamilton and at Norwich;† and *Phacops rana* (Green) Hall, is reported doubtfully from the Upper Helderberg and occurs in the Marcellus, Hamilton, Tully limestone, and Chemung. Consequently it is clear that so far as the fossils are concerned this list shows a closer relationship with the "Ithaca group," as stated by Vanuxem in 1842,‡ than with any other stage. To be sure most of the species occur in the Hamilton stage, but so do the majority of the species found in the "Ithaca group" at Ithaca, and judged by that alone the zone might be referred to the Hamilton instead of the Portage where its stratigraphical position and other evidence show it to belong.

At Norwich, six miles south of North Norwich, the base of this zone has been carried by the dip below the surface. A number of observations along the Chenango valley indicate the dip to be between 35 and 40 feet per mile for that region. The high hill west of Norwich affords a good section of 550 feet. At the base of the hill on the Canaswacta creek are the lowest rocks, at an approximate elevation of 985′, which are bluish rather arenaceous shales containing fossils. At 1140′ is the base of an old quarry which runs up to 1193′ and in this quite a good many fossils were found. The most common species are *Paracyclas lirata* Con., *Chonetes scitula* Hall, *Tropidoleptus carinatus* Con., *Rhynchonella Stephani* Hall (?) and *Atrypa reticularis* (Linné) Dal. At 1230′ are the last shales containing fossils below the reds and grays. The most abundant fossils are segments of crinoid stems, but with these are specimens of *Paracyclas lirata* Con. and *Cypricardella* (*Microdon*) *bellistriata* (Con.) Hall. At 1262′ are rather fine fissile shales which are succeeded by coarse sandstones at 1370′. A prominent concretionary sandstone occurs at 1410′ and at 1460′ is a coarse gray sandstone. The first red shale resting on thin fissile olive shales, occurs at 1475′ and in the red shales at about 1479′ is a somewhat calcareous layer with pebbles containing numerous fish scales which are found to a less extent in the red shales close to this stratum. The red shale stops

* Pal. N. Y., vol. v, Pt. I, Lamell. II, p. 468.

† *Ibid.*, Lamell. I, p. 177.

‡ See Geol. N. Y., Pt. III, p. 178, where this quarry is described under the head of the Ithaca group.

near the altitude of 1500′ and is succeeded by coarse gray sandstone which continues to the top of the hill with an approximate altitude of 1555′. At 1535′ is Crandall's flagstone quarry in coarse gray sandstone. In a cut on the D. L. & W. R. R. less than one-half mile north of the station, and in the quarries along Ransford creek, toward the reservoir northeast of the village, are excellent places for collecting fossils.

In a small creek about one mile north of Oxford or seven miles southwest of Norwich are exposures of shale containing the same fauna as at Norwich, though this is near the upper part of the zone which soon disappears beneath the surface. On the eastern side of the Chenango valley, at the Lyon Brook Bridge of the O. & W. R. R. is a good section showing the top of the Oneonta zone in the creek below the bridge with the lowest red shales about 150 feet higher, in an old quarry just east of the south approach to the bridge. This section was briefly described by Dr's C. E. Beecher, J. W. Hall and Mr. C. E Hall.* In addition to the species mentioned, the writer found fronds of *Archæopteris* in the lower red shale near the railroad bridge, while still higher, in the zone of the Oneonta sandstone in the first R. R. cut north of the 218th mile post, are specimens of *Amnigenia catskillensis* (Van.) Hall, and plates of *Holonema rugosa* (Claypole) Newb.† Between Oxford and the summit on the O. & W. R. R. and about one-sixth of a mile west of the 214th mile post, is a cut through red and greenish shales in which fossils occur as described in the above mentioned report. One-quarter of a mile east of the Summit in another R. R. cut are greenish and olive shales containing numerous fossils overlying the Oneonta sandstone.

A similar section may be constructed along the Susquehanna River from Oneonta to Bainbridge. In the Anthony White quarry, at the foot of the high hill just west of Oneonta, are abundant fossils that belong in the "Oneonta group" of Conrad, which continues up the hill for about 200 feet, the upper portion being composed of the Oneonta sandstone of Vanuxem. The rocks at the base of this hill, or Conrad's "Oneonta group," were correlated quite accurately by Vanuxem, who stated that he supposed them to belong to the "Ithaca group."‡ Through the kindness of Dr. H. S. Williams I am able to quote from his Ms. list of the fossils collected in the Anthony

* Fifth Ann. Rep. State Geologist [N. Y.] 1885, p. 11; see page 4 for credit.

† For an account of these plates see Dr. H. S. Williams in Proc. Am. Assoc. Adv. Sci., vol. xxxix, p. 337; Prof. Claypole in Am. Geologist, vol. vi, pp. 255–257, and Prof. Cope in Proc. U. S. Nat. Mus., vol. xiv. p. 456.

‡ Geol. N. Y.. Pt. III, p. 192. The clause reads, "the base of which [hill] is composed of rocks which I have supposed to belong to the Ithaca group."

White quarry. The zone is called the *Paracyclas lirata* stage of the Hamilton fauna and its stratigraphic position was shown by Dr. Williams in 1885.* A list of these species with their geologic range is given below.

Number of Species.	Fauna of Conrad's "Oneonta group" at Oneonta, New York. List of Species.	Geologic Stage.† Upper Helderberg.	Marcellus.	Hamilton.	Hamilton of eastern New York.‡	Portage.§	Ithaca.‖	Oneonta.¶	Portage of eastern New York.	Portage of eastern Pennsylvania.**	Chemung.
		1	2	3	4	5	6	7	8	9	10
1	*Microdon* (*Cypricardella*) *bellistriata* (Con.) Hall	--	--	×	×	--	×	--	--	×	×
2	*Paracyclas lirata* (Con.) Hall	--	--	×	×	--	--	×	×	×	--
3	*Tropidoleptus carinatus* (Con.) Hall	--	--	×	×	×	--	×	×	×	×
4	*Palæoneilo maxima* (Con.) Hall	--	--	×	×	--	--	--	--	×	--
5	*Grammysia magna* Hall	--	--	×	×	--	×	--	--	--	--
6	*Grammysia bisulcata* (Con.) Hall	--	--	×	×	--	--	--	--	--	--
7	*Cimitaria recurva* (Con.) Hall (?)	--	--	×	--	--	--	×	--	--	--
8	*Tellinopsis subemarginata* (Con.) Hall	--	--	×	×	--	--	--	--	--	--
9	*Modiomorpha concentrica* (Con.) Hall	--	--	×	×	--	?	--	--	--	--
10	*Spirifera mucronata* (Con.) Bill	--	×	×	×	--	--	--	?	--	--
11	*Goniophora carinata* (Con.) Hall	--	--	--	--	--	--	×	--	?	--
12	*Homalonotus De Kayi* (Green) Emm.	--	×	×	×	--	--	--	×	×	--
13	*Nuculites triqueter* Con.	--	?	×	--	--	--	--	--	--	--
14	*Microdon* (*Cypricardella*) *gregarius* Hall	--	--	×	×	--	×	--	×	×	×
15	*Leptodesma Rogersi* Hall	--	--	×	×	--	--	×	--	?	--
16	*Leiopteria De Kayi* Hall	--	--	×	×	--	--	--	--	--	--
17	*Orthonota undulata* Con.	--	--	×	×	--	--	--	--	--	--
18	*Microdon* (*Cypricardella*) *complanatus* Hall	--	--	×	×	--	--	×	--	--	--
19	*Pleurotomaria sulcomarginata* Con.	×	--	×	×	--	--	--	--	--	--
20	*Spirifera mesastrialis* Hall	--	--	×	×	--	×	--	×	×	×

* Proc. Am. Assoc. Adv. Sci., vol. xxxiv, Chart of Meridional Sections of the Upper Devonian deposits of New York, Pennsylvania and Ohio, Section X, A′; where the *Paracyclas* fauna (A′), is shown immediately underlying the Oneonta reds and grays, (F′).

† The data used in showing the geologic range of the species in the above list are derived principally from the various works of Professors Hall, H. S. Williams and Prosser. The distribution is confined to New York and eastern Pennsylvania which have been studied with such care that the evidence can be used with considerable force in this correlation. The range of a portion of the species reported from the Portage of eastern New York and Pennsylvania depends upon lists of the author, which have not yet been published. The horizon of this eastern fauna is clearly above the Hamilton, but we have not yet sufficient evidence to attempt its correlation with the different zones of the Portage in central and western New York.

‡ The horizon of the species reported by Professor Hall, and some other authors, from the Hamilton of eastern New York is believed to require further investigation. The writer has evidence showing that a portion of these localities really

Of the twenty species named in the above list fourteen are known to occur above the Hamilton, while five of the remainder are reported from the Hamilton of eastern New York, which as stated above needs revising since some of the so-called Hamilton horizons are in the Portage, and only one species so far as previously known occurred no higher than the Hamilton stage.

At Sidney, twenty-one miles southwest of Oneonta, the top of the Oneonta sandstone is reached in the hill forming the divide between the Susquehanna and Unadilla Rivers northwest of the village.

In Secor's quarry, about 140 feet above the railroad level at Sidney* are grayish to olive standstones with greenish and bluish argillaceous shales. Plant and crinoid stems were found in the debris of the quarry, while near the top of the hill are loose slabs, with no indications of having been moved any considerable distance, containing poorly preserved specimens of *Leiorhynchus* and Lamellibranchs. At New Berlin Junction on the Ontario & Western R. R., two miles from Sidney, or at Bainbridge five miles down the Susquehanna River are numerous specimens of fossils which in both cases overlay the zone of the Oneonta sandstone.

The difficulty in correlating these deposits in which part of the stratigraphic series has disappeared and paleontologically many of the species common in the rocks below reappear in the higher rocks, in some cases unchanged and again slightly modified, may be overcome, it is believed, by carefully studying both the fauna and the stratigraphic relations of the rocks. This test has been made by the writer in southeastern New York and eastern Pennsylvania, where in the absence of the Tully limestone and Genesee shale, the problem is about the same as that presented along the Susquehanna River valley, and he believes it possible to separate the Hamilton from the overlying rocks of Portage age by the faunas contained in the respective stages.

belongs stratigraphically above the horizon of the Tully limestone and Genesee shale. Consequently it was considered best to give a separate column to those species separated from the Hamilton of eastern New York, some of which should probably be credited to the Portage.

§ Most of the species given in this column are from central and western New York.

‖ Mainly from Ithaca and vicinity, forming the middle Portage of that region.

¶ This is the Oneonta zone of Conrad and the occurrence of the species at other localities than Oneonta, mainly from Norwich and Mt. Upton, Chenango County, is given.

** The species reported from the Portage of eastern New York and Pennsylvania are mainly from my own lists.

* Elevation of station at Sidney 992′ A. T.

The Pennsylvania geologists have been inclined to call the upper stage Chemung,* while some of the official geologists of New York have called the same rocks Hamilton, because certain species of fossils more or less common in the Hamilton stage occur in these rocks. At the Washington meeting of the International Congress of Geologists, a series of these fossils arranged in their stratigraphic order was exhibited to several geologists and Dr. H. S. Williams recognized the difference in age, thus proving that a careful study of these faunas will enable one to separate them.

In order to show the nature of this fauna, a list of the species noted along the Delaware River above Port Jervis, New York is given. From the Hamilton were obtained:—

1. *Spirifera granulifera* Hall .....(*aa*)
2. *Spirifera mucronata* (Con.) Bill..(*aa*)
3. *Tropidoleptus carinatus* (Con.) Hall .....(*aa*)
4. *Orthis Vanuxemi* Hall .....(*a*)
5. *Chonetes coronata* (Con.) Hall ...(*r*)
6. *Ambocœlia umbonata* (Con.) Hall (*rr*)
7. *Leiorhynchus multicosta* Hall...(*rr*)
8. *Chonetes setigera* Hall.....(*a*)
9. *Chonetes scitula* Hall .....(*c*)
10. *Nucleospira concinna* Hall.....(*rr*)
11. *Athyris spiriferoides* (Eaton) Hall (*rr*)
12. *Cyrtina hamiltonensis* Hall.....(*rr*)
13. *Palœoneilo constricta* (Con.) Hall (*r*)
14. *Nuculites triqueter* Con. .....(*rr*)
15. *Palœoneilo emarginata* (Con.) Hall .....(*rr*)
16. *Nucula bellistriata* (Con.) Hall...(*rr*)
17. *Palœoneilo muta* Hall.....(*rr*)
18. *Palœoneilo maxima* (Con.) Hall..(*rr*)
19. *Nucula corbuliformis* Hall .....(*rr*)
20. *Nuculites cuneiformis* Con.....(*rr*)
21. *Goniophora hamiltonensis* (Hall) Mill. .....(*rr*)
22. *Microdon* (*Cypricardella*) *tenuistriatus* Hall (?) .....(*r*)
23. *Tellinopsis subemarginata* (Con.) Hall .....(*rr*)
24. *Pholadella radiata* (Con.) Hall ..(*rr*)
25. *Leda diversa* Hall.....(*rr*)
26. *Grammysia bisulcata* (Con.) Hall (*rr*)
27. *Cimitaria corrugata* (Con.) Hall..(*rr*)
28. *Actinopteria Boydi* (Con.) Hall .(*rr*)
29. *Modiomorpha concentrica* (Con.) Hall .....(*rr*)
30. *Microdon* (*Cypricardella*) *bellistriatus* (Con.) Hall .....(*rr*)
31. *Nuculites oblongatus* Con. .....(*r*)
32. *Grammysia constricta* Hall.....(*rr*)
33. *Orthonota undulata* Con.....(*rr*)
34. *Paracyclas lirata* (Con.) Hall ...(*rr*)
35. *Orthonota* (?) *parvula* Hall .....(*r*)
36. *Modiella pygmœa* (Con.) Hall ...(*rr*)
37. *Pterinea flabellata* (Con.) Hall ..(*rr*)
38. *Leda rostellata* (Con.) Hall.....(*rr*)
39. *Glyptodesma erectum* (Con.) Hall..(*rr*)
40. *Hyolithes actis* Hall .....(*rr*)
41. *Tentaculites bellulus* Hall .....(*r*)
42. *Coleolus tenuicinctum* Hall.....(*rr*)
43. *Cyrtolites* (*Cyrtonella*) *pileous* Hall .....(*rr*)
44. *Loxonema hamiltoniæ* Hall.....(*rr*)
45. *Bellerophon Leda* Hall.....(*rr*)
46. *Bellerophon acutilirata* Hall ....(*rr*)
47. *Homalonotus DeKayi* (Green) Emm. .....(*rr*)
48. *Dalmanites* (*Cryphæus*) *Boothi* (Green) Hall (?) .....(*rr*)
49. *Psilophyton princeps* Dn.....(*rr*)

The fossils of the above list were all collected from exposures along the Delaware River or the neighboring hills not more than two and one-half miles above Port Jervis. The age of the formation is Hamilton, although it has been mapped and described as Hamilton and Genesee.†

* For a discussion of a section in reference to this view see an article by Prosser in this Journal, vol. xliv, p. 210, where the question is discussed in detail.

† See 2d Geol. Survey Penna. G^6, p. 194, and especially the geological map of Pike and Monroe counties accompanying this report.

The next higher zone is well exposed along the south bank of the river both below and above the N. Y., L. E. & W. R. R. bridge, three miles northwest of Port Jervis. The following species were obtained from this locality :—

1. *Spirifera mesastrialis* Hall ....(*rr*)
2. *Palæoneilo emarginata* (Con.) Hall ....(*rr*)
3. *Leda diversa* Hall....(*r*)
4. *Microdon (Cypricardella) tenuistriata* Hall (?) ....(*rr*)
   Possibly it is *M. gregarius* Hall, but it resembles the former more closely.
5. *Orthonota carinata* Con.....(*rr*)
6. *Palæoneilo plana* Hall.....(*rr*)
7. *Paracyclas lirata* (Con.) Hall..(*rr*)
8. *Grammysia subarcuata* Hall (?) (*rr*)
9. *Modiomorpha subalata* (Con.) Hall var. *chemungensis* Hall (?) ..(*rr*)
10. *Actinopteria Boydi* (Con.) Hall..(*a*)
11. *Homalonotus DeKayi* (Green) Emmons....(*rr*)

The zone from which the above species were obtained was called Chemung by the Pennsylvania Survey;* still the fauna is not a Chemung but a modified Hamilton one and the zone belongs to the Portage stage of central and eastern New York.

It seems clear to the writer that the above lists of fossils with the statement of their stratigraphic position show that the fossiliferous zone underlying the Oneonta sandstone in Chenango and Otsego counties is not the top of the Hamilton but belongs in the Portage stage. It appears to be well established by careful study that the typical Hamilton fauna and the higher or modified faunas, when considered in connection with their stratigraphic position, may be traced for a long distance across eastern New York and Pennsylvania. The facts briefly described in this paper, which have required a considerable amount of investigation and study, are commended to the attention of those engaged in the preparation of the new geologic map of New York.

Topeka, Kansas, May, 1893.

* *Ibid.*, p. 194, where it is stated that the Chemung commences about one-half mile above the Erie railroad bridge and continues down the river for nearly two miles. See also the geological map with the report.

ART. XXXIV.—*On the Estimation of Chlorates and Nitrates, and of Nitrites and Nitrates in one operation;* by CHARLOTTE F. ROBERTS.

[Contributions from the Kent Chemical Laboratory of Yale College—XXVII.]

A RECENT paper by Gooch* and Gruener has shown that nitrates may be estimated most accurately by treatment with manganese chloride, the chlorine thus liberated being collected in potassium iodide, and the amount of iodine set free determined by titration with sodium thiosulphate. In a late number of this Journal,† I have shown that good results are also obtained by treatment of the nitrate with ferrous chloride, and collecting and measuring the nitric oxide evolved over sodium hydroxide with the apparatus described and pictured in that article.

This apparatus consists essentially of a small retort fitted with a hollow, ground-glass stopper prolonged beneath in a tube, and joined above with two branching tubes through one of which carbon dioxide may enter, and the other of which is attached to a funnel-tube with stop-cock, through which liquids may be introduced without admitting air. The retort is connected with a small condenser, which in turn is attached to a Will and Varrentrapp tube containing potassium iodide, and this with a Hempel's burette containing a strong solution of sodium hydroxide. In the experiments described, the potassium nitrate was introduced into the retort, carbon dioxide passed through until the air was completely driven out, and then ferrous chloride added through the funnel-tube. After heating, and passing a current of carbon dioxide through the apparatus, the volume of gas unabsorbed by sodium hydroxide was measured at the observed temperature and pressure, and from this the weight of potassium nitrate was calculated. This is merely a special form of a very common method of estimating nitrates, but the apparatus is in a form which can be conveniently handled and which readily adapts itself to other uses beside the simple determination of nitrates. In a mixture of chloric and nitric acids, for example, it becomes possible by a combination of the two above-named methods for estimating nitrates, and the use of the apparatus described, to determine in one operation the amounts of each present. A method for the determination of chlorates which has long been in common use consists in treatment with hydro-

* This Journal, vol. xliv, 117.
† Vol. xlvi, p. 126, August, 1893.

chloric acid, the liberated chlorine being conducted into potassium iodide, and the iodine set free determined by titration with sodium thiosulphate. This method is entirely analogous to the first mentioned method of determining nitrates, the only difference being that in the latter case a solution of manganous chloride in hydrochloric acid is used instead of the acid alone. In case of the nitrate, however, there is a second product, nitric oxide, which may be collected and measured. It would then seem possible, with the use of the apparatus heretofore described, to treat a mixture of a chlorate and nitrate with manganous chloride, pass the resulting gases through potassium iodide, and then into the Hempel's burette. The amount of nitric oxide will give at once the amount of nitrate present. The iodine liberated will give the total chlorine set free by the reduction of the nitrate and chlorate. After that which is due to the nitrate determined has been deducted, we have an exact measure of the chlorate present.

To verify these presumptions, a few preliminary experiments were first made with potassium chlorate alone. In these, and all of the following experiments, great care was taken that the escaping gases should only come in contact with glass. Between the condenser and Hempel's burette were two Will and Varrentrapp tubes sealed together and containing potassium iodide, and generally a Geissler bulb containing potassium iodide was also added to make sure that no chlorine escaped absorption. The potassium chlorate was weighed out and introduced into the retort, air driven out by carbon dioxide, and then manganous chloride added through the funnel-tube. The liquid became dark at once, and a short heating sufficed to restore it to its original clear, light-green color. When this was accomplished, a current of carbon dioxide was passed through the apparatus, the bulbed tubes were disconnected, and their contents titrated with sodium thiosulphate. The following results were obtained from five trials:

	Wt. $KClO_3$ taken.	Wt. $KClO_3$ found.	Difference.
(1)	0·1000	0·0990	0·0010
(2)	0·1000	0·0995	0·0005
(3)	0·0500	0·0484	0·0016
(4)	0·0500	0·0498	0·0002
(5)	0·0500	0·0496	0·0004

Working in the same way with a mixture of potassium chlorate and potassium nitrate, and estimating the amount of nitrate first from the nitric oxide produced, the following results were obtained:

		Weights taken.	Weights found.	Difference.
(1)	Potassium chlorate	0·0500	0·0515	0·0015
	Potassium nitrate	0·0500	0·0494	0·0006
(2)	Potassium chlorate	0·0500	0·0508	0·0008
	Potassium nitrate	0·0500	0·0493	0·0007
(3)	Potassium chlorate	0·1000	0·0987	0·0013
	Potassium nitrate	0·1000	0·0995	0·0005
(4)	Potassium chlorate	0·1000	0·1007	0·0007
	Potassium nitrate	0·1000	0·0980	0·0020
(5)	Potassium chlorate	0·0300	0·0305	0·0005
	Potassium nitrate	0·1000	0·0990	0·0010
(6)	Potassium chlorate	0·1000	0·1006	0·0006
	Potassium nitrate	0·0300	0·0293	0·0007

The method is simple, rapid, and easy, and sufficiently accurate for most analytical work. One objection that may be urged against it is that any error in the determination of the nitric acid involves a corresponding error in the amount of chloric acid, but the above results show that such errors will be quite small if the experiment is conducted with proper precautions.

It also appeared probable that a nitrate and nitrite could be estimated at one operation in a somewhat similar manner. By the action of manganous chloride on a mixture of nitric and nitrous acids, nitric oxide and iodine would be set free from each. Representing the weight of nitric oxide found by a, and the weight of iodine found by b, and letting x equal the amount of nitric acid operated upon, and y the amount of nitrous acid,

$$\frac{30}{63}x + \frac{30}{47}y = a, \text{ and}$$

$$\frac{379{\cdot}5}{63}x + \frac{126{\cdot}5}{47}y = b$$

whence,

$$x = 0{\cdot}249\,b - 1{\cdot}049\,a$$
$$y = 2{\cdot}35\,a - 0{\cdot}186\,b$$

In the attempt to verify these formulas by experiment, a little difficulty was found in getting a pure and stable nitrite upon which to operate. Some silver nitrite was prepared by precipitation from potassium nitrite and silver nitrate. This was washed well and dried as thoroughly as possible over sulphuric acid in the dark. Weighed portions were put in the retort, and after the air was expelled, manganous chloride was added. The amount of silver nitrate was then estimated from the iodine set free in the bulbed tubes, and also from the nitric

oxide left in the Hempel burette. The results varied from one another by 4 or 5 per cent on different portions, but a few trials were sufficient to indicate that the trouble lay in the silver nitrite and not in the process itself. The percentage of purity as obtained from several trials by ignition was 98·4 per cent. The average of ten trials estimating from nitric oxide gave 98·1 per cent, and from the liberated iodine 98·7 per cent. This was uniformity enough to indicate that the method of work was trustworthy, although there was apparently such a lack of homogeneity in the silver nitrite as to make it impossible to use it in testing the value of the formula given above.

To obviate this difficulty, more silver nitrite was precipitated, well washed, dissolved in warm water, and a solution of sodium chloride added. The silver chloride was then filtered off, and the resulting solution of sodium nitrite was used in the following experiments. To determine the strength of this solution, ten or fifteen cubic centimeters were drawn off from a burette, and the nitrite estimated with potassium permanganate according to the method of Kinnicutt and Nef.* At the same time, similar amounts were introduced into the retort with manganous chloride, and the nitrite estimated both from the liberated iodine and the nitric oxide formed. It was found that the air must be thoroughly driven out of the apparatus before the nitrite was introduced, as the carbon dioxide, passing over the solution, decomposed it with liberation of nitric oxide which, in presence of air, gave an excess of free iodine, and at the same time a little gas was lost. Accordingly, carbon dioxide was first passed through the apparatus for some time, then the nitrite was introduced through the funnel-tube and rinsed in with a little water, followed by the manganous chloride solution, care being taken that the water should not exceed one-third of the total volume of the liquid, according to the precaution to be shown necessary by Gooch and Gruener. Working in this way with the solution of sodium nitrite, the following results were obtained :

	Vol. taken. cm.	Weight reckoned from $KMnO_4$. grm.	Weight reckoned from NO. grm.	Weight reckoned from iodine. grm.
(1)	10	0·0463	0·0456	0·0450
(2)	10	0·0460	0·0460	0·0470
(3)	15	0·0704	0·0708	0·0722
(4)	15	0·0690	0·0712	0·0750
(5)	15	0·0701	0·0704	0·0722
(6)	15	0·0688	0·0696	0·0695
(7)	15	0·0706		
(8)	15	0·0712		

* Ann. Chem. Journ., v, p. 388.

It will be seen that the results reckoned from the iodine are in general larger than those obtained by either of the other methods. This is what might be expected on account of the difficulty of completely removing air from the apparatus and solutions employed, and such air would naturally cause an excess of iodine. In (4) especially it will be noticed that we have an abnormally large amount of iodine set free, and this may undoubtedly be attributed to air, since it was observed that the current of carbon dioxide was rather sluggish at the time of that experiment.

The average of the above-recorded experiments would give as the value of fifteen cubic centimeters, from the method of Kinnicutt and Nef, ·0697 grams, from the nitric oxide, ·0699 grams, and from the iodine ·0711 grams. If we assume that the mean weight per fifteen cubic centimeters is represented by the average of these three modes of determination, we obtain 0·0702 grams, and that is the number which is used in the following determinations to represent the weight of sodium nitrite in fifteen cubic centimeters of the solution. The following experiments were made in the same way as the preceding, except that potassium nitrate was introduced in the dry state before the air was driven out of the apparatus, and the results were calculated from the formula given above.

		Weights taken.	Weights found.	Difference.
(1)	Sodium nitrite	0·0702	0·0718	0·0016
	Potassium nitrate	0·1000	0·1000	0·0000
(2)	Sodium nitrite	0·0702	0·0712	0·0012
	Potassium nitrate	0·1000	0·0999	0·0001
(3)	Sodium nitrite	0·0702	0·0710	0·0008
	Potassium nitrate	0·1000	0·1004	0·0004
(4)	Sodium nitrite	0·0702	0·0698	0·0004
	Potassium nitrate	0·1000	0·1012	0·0012
(5)	Sodium nitrite	0·0468	0·0453	0·0013
	Potassium nitrate	0·1000	0·0994	0·0006
(6)	Sodium nitrite	0·0468	0·0444	0·0024
	Potassium nitrate	0·0500	0·0513	0·0013

Though the process is one in which the most perfect accuracy cannot be assured in all cases, the above results show that it is capable of giving fairly accurate results, sufficient for many analytical purposes. It seems to be especially well adapted to the estimation of the commercial alkali nitrites, the whole determination being made on one portion and by one operation, instead of on two different portions.

Art. XXXV.—*Alphonse DeCandolle.*

Alphonse Louis Pierre Pyramus DeCandolle, the son of Augustin Pyramus DeCandolle, was born on the 28th of October, 1806, and died in his eighty-seventh year, on the 4th of last April (1893). His father, born in 1778, published his first botanical work in 1799; thus the scientific activity of these two remarkable botanists covers nearly a full century.

Casimir, the son of Alphonse, has contributed not only to systematic botany but also to the philosophy of the subject, in striking treatises on leaf arrangement and on the morphology of the leaf itself. There are therefore three generations of botanists, by the last of whom the century is, we may hope, to be more than rounded out.

Augustin, of the first generation, was widely known for his concise and clear exposition of the fundamental principles of vegetable morphology, as well as for his comprehensive endeavor to describe all known flowering plants. It is interesting to note that in the same field of exposition, Alphonse, of the second generation, began his philosophical work. The Théorie Élémentaire of the father is fitly followed by the Traité Élémentaire of the son. The latter treatise, commonly known as the Introduction, was published in 1835, in two volumes covering the essential principles of pure and applied botany. An unauthorized edition, in one volume, was published in Brussels, in 1837, and the work has been translated into the principal continental languages. Those who look carefully into this compact treatise, knowing what its author subsequently accomplished, will see clear indications of symmetrical development, together with a marked tendency to investigate speculative aspects of the different branches of the subject. One phase of the subject possessed for him such strong attraction that he published, one year later, than the Introduction, a small work on the Distribution of Food-plants. Thus while aiding his father in the elaboration of the natural orders for the Prodromus, he was engaged in attacking philosophical questions of the greatest importance. We must say once for all that his interest in Systematic Botany, as evinced in the countless pages either written or edited by himself, did not flag even up to the very last; but with all this extraordinary activity in Systematic Botany, he was busy with every conceivable collateral speculation, always so bold and yet conservative, as to keep the confidence even of those who could not follow him. This speculative tendency is shown most strikingly in the great Botanical Geography, published by him in 1855. This vast work consists of well arranged facts brought together with untiring assiduity from all possible quarters. As the first volume draws to its close, it is seen that the clue which the author

thought he had well in hand has failed him, and from that time on there is hint after hint of some new way out of the difficulty of accounting for apparent caprice in the distribution of plants. Now that one can read his work in the light which has come from the luminous suggestions of Darwin and of Wallace, we can easily understand how gladly the author accepted the hypothesis of derivation through Natural Selection. From our point of view we can now see how near he came to making this fertile suggestion himself; one can almost believe that at times he had the very clue in hand. His acceptance of Darwinism, as he understood it, was unreserved, but it was not always the Darwinism of Darwin. In regard to the two important matters, of inheritance of acquired characters, and of vagueness or directness in development, he entertained views which are not accepted by some of Mr. Darwin's followers; but he claims that his interpretation is justified not only by the facts, but by Mr. Darwin's own words. These views are presented with remarkable perspicuity in a work on the History of two Centuries of Science and of Scientific Men. This treatise is preceded and followed by studies on other subjects, particularly in regard to Natural Selection as applied to man. This work was first issued in 1873: a revised edition followed after the lapse of twelve years. During that time he had not changed his opinions to any great extent, but he had the satisfaction of withdrawing from the second edition, as unnecessary, a defence of Darwinism which he had made in the first, because in 1885 among his French contemporaries he stood no longer alone as a Darwinian. He accomplished in France what Dr. Gray effected here, and Bentham and Hooker in England, namely the conversion of botanists to the belief that in Darwinism is found a safe working hypothesis by which one can account for the anomalies in distribution.

A word respecting some of the other subjects discussed in the volume devoted to the History of Science may be given conveniently at this point. These titles are, (1) Concerning observation of facts in schools and later. (2) On observation of social facts. (3) On statistics. (4) On the influence of heredity, variability, and selection in the human species, and on the probable future of this species. (5) On alternations in the intensity of epidemics, and in the value of prophylactic measures against them. (6) Which of the modern languages will be the dominant one in the 20th century? (His answer is, English.) (7) On the different meanings of the word "nature" and its derivatives. The chief essay, which gives its name to the volume, On the History of Science and Scientific Men for two Centuries, is devoted to a discussion of the influences exerted by surroundings, such as country, climate and social conditions, on the production of scientific men. It is, in short, a social study, somewhat after the type of Mr. Galton's English Men of Science, their Nature and Nurture. He makes a broad distinction between the faculties of a high order which are attributable to heredity and those which

manifest themselves for the first time in a family, and are to be regarded as individual variations. This briefest possible analysis of the volume on History indicates sufficiently the wide range of DeCandolle's inquiries, but it cannot give even an intimation of the marvellous charm of style of which he was a master.

We turn now to a consideration of his Phytography. A work designed to give instruction in methods of describing plants would be thought necessarily technical and dry. But every page of this work possesses attraction not only for botanists but for students in all fields of thought. The methods which he deals with are applicable, *mutatis mutandis*, to other branches of science. He gives many hints as to methods of accumulating facts from different sources, and imparts as far as one can do so, the secret of winnowing wheat from the chaff. He lets us into the mysteries of his cabinet, in which he stored myriads of facts for his systematic treatises and for his geographical botany. Our readers will hardly agree with all his views as to the relative value of different appliances for botanical research, but every one must be struck by the fairness with which personal views are presented.

In 1883, appeared his treatise on the Origin of Cultivated Plants. This has been translated in the so-called International Series and is doubtless familiar to all of our readers. It illustrates the extraordinary scope of his observation and reading, and his judicial method.

We have deferred until the last a notice of his Laws of Botanical Nomenclature. At the Paris International Botanical Congress, held August 16–26, 1867, he presented for consideration a system of rules to govern botanical nomenclature. This body of laws was discussed first by a special committee, and then by the whole Congress. With some modifications the system was adopted. The Code, accompanied by a commentary, was published by DeCandolle that autumn; sixteen years later, he published (1883) amended laws, together with some suggested changes, and a concise review of the discussions to which the laws had given rise.

Article 15 relates to the vexed question of priority. It reads, "Each natural group of plants can bear in science but one valid designation, the most ancient, whether adopted or given by Linnæus, or since Linnæus, provided it be consistent with the essential rules of nomenclature." According to this, DeCandolle would make for generic names a fixed date, 1737, that of the publication of the first edition of the Genera plantarum: while species should date from the publication of the first edition of the Species plantarum, namely, 1753.

Carried out to its logical conclusions and without regard to conservative and traditional usage, this has opened the door to the introduction of what may well be deplored as unnecessary confusion. That which was dreaded by many has already happened: already there are at least two schools among those who have cut loose from traditional methods and have adopted

certain dates or one date only as the point of departure in priority. The chaotic condition preliminary to a cosmos is fairly upon us. Exactly when and how and where from this confusion an orderly arrangement can arise it is at present impossible to tell.

Certain it is that all botanists would do well to preserve, throughout the present and the coming days of disorder, that freedom from prejudice which characterized all of Alphonse DeCandolle's work. If everyone, who rushes in fearlessly to take a hand in changing the names of plants, would bear in mind the cautions given in the Phytography, it would save many from mortification when the time comes for exact and enduring work to be sifted from that which is hasty, superficial and ephemeral.

G. L. G.

SCIENTIFIC INTELLIGENCE.

I. Geology and Natural History.

1. *Minnesota Geological and Natural History Survey.*—A notice of the publication of the memoir of E. O. Ulrich on the Bryozoa of Minnesota, constituting a part of volume III of the final Quarto Report of the Minnesota Geological Survey, is given in the last volume of this Journal. More recently, the following parts of the same volume have been issued:

Sponges, Graptolites and Corals from the Lower Silurian of Minnesota, by N. H. Winchell and Charles Schuchert. 42 pp. 4to, with 2 plates.

. *The Lower Silurian Brachiopoda of Minnesota*, by N. H. Winchell and Charles Schuchert. 144 pp. 4to, with 6 plates.

Prof. Winchell's Twentieth Annual Report for the year 1891, published during the current year, contains a paper by him on the Crystalline rocks, containing "some preliminary considerations as to their structure and origin," and another of 70 pages on the Mesabi Iron Range; Field observations on certain granite areas by N. S. Grant; a paper on the abandoned strands of Lake Superior, 110 pages, with many illustrations, by A. C. Lawson; on the Diatomaceæ of Minnesota in interglacial peat, by B. W. Thomas, with a list of species and notes by H. L. Smith.

2. *Paleontology of New York*, Volume VIII, Part 2, Fascicle 1, by Prof. James Hall, assisted by J. M. Clarke. 176 pp. 4to. —This new part of Vol. VIII contains a continuation of Professor Hall's "Introduction to the Study of the Genera of the Palæozoic Brachiopoda." The names of the accepted genera and subgenera here discussed and described are *Spirifer*, *Cyrtia*, *Cyrtina*, *Syringothyris*, *Spiriferina*, *Ambocœlia*, *Metaplasia* (n. g.), *Whitfieldia* (n. g.), *Hyattella*, *Dayia*, *Hindella*, *Meristina*, *Merista*, *Meristella*, *Charionella*, *Pentagonia*, *Camarospira*, *Athyris*, *Cliothyris*, *Actinochonchus*, *Seminula*, *Spirigerella*,

Kayseria, *Retzia*, *Rhynchospira*, *Ptychospira* (n. g.), *Uncites Eumetria*, *Acambona*, *Hustedia* (n. g.), *Uncinella*, *Trematospira*, *Parazyga*, *Anoplotheca*, *Coelospira*, *Leptocoelia*, *Vitulina*, *Anabaia*, *Nucleospira*, *Cyclospira* (n. g.), *Glassia*, *Zygospira*, *Catazyga* (n. g.), *Atrypina*, *Atrypa*, *Gruenewaldtia*, *Karpinskia*. Other names appear in the very full synonymy. Many figures of distinguishing characteristics are given in the text, and plates xxi to lii are referred to which will be contained in the completed volume.

3. *Salt and Gypsum Industries of New York*, by F. J. H. MERRILL, Assistant State Geologist. Bulletin of the N. Y. State Museum, vol. iii, April, 1893, 90 pp. 8vo, with maps, plates and sections.—Prof. Merrill treats briefly of the geological part of his subject, and illustrates it with maps showing the distribution of salt and brine wells as ascertained by borings. The economical subjects are discussed with great fullness and with numerous illustrating plates and figures.

4. *Bionomie des Meeres:* Beobachtungen über die marinen Lebensbezirke und Existenzbedingungen; von JOHANNES WALTHER. First part, an Introduction to Geology as a historical science. 196 pp., 8vo. Jena, 1893 (Gustav Fischer).—Professor Walther, of Jena, treats in this very instructive volume, in a concise and systematic way, of the conditions of existence and range of marine life, with reference to the bearing of the subjects on geology. Some of the topics discussed, and illustrated by citations of physical and biological facts, are the following: The marine conditions connected with the arrangements of the continents, with their bays, estuaries, etc., and with the oceans, of varying depths, from the coasts downward, and of varying temperatures and varying kinds of sea-bottom and other living conditions; the influence of light and heat on growth and distribution; of salinity (with relation to which the author divides marine animals into the *Stenohaline*, or those requiring waters having the normal salinity of the ocean, the *Euryhaline*, or those capable of enduring a wide range, from brackish water to the normal, and the *Brack-water*, or those of brackish water); the influence of tides and waves; of currents and the general circulation; and many other points of special geological importance. Students in geology would profit much by the careful study of Prof. Walther's work. It promises well for the future parts of his Introduction to Historical Geology.

5. *North American Fauna*, No. 7. *The Death Valley Expedition: a Geological survey of parts of California, Nevada, Arizona, and Utah.*—Part II, containing Reports on different departments by A. K. FISHER, L. STEJNEGER, C. H. GILBERT, C. V. RILEY, R. E. C. STEARNS, C. H. MERRIAM, T. S. PALMER. Published by authority of the Secretary of Agriculture. 394 pp. 8vo, with 14 plates, 1 large map and 4 small maps illustrating geographical distribution.

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CONTENTS.

Page.

ART. XXIII.—Fireball of January 13th, 1893. By H. A. NEWTON. (With Plate III) 161

XXIV.—Photometric Method which is independent of Color; by O. N. ROOD 173

XXV.—Actinolite-Magnetite Schists from the Mesabé Iron Range, in Northeastern Minnesota; by W. S. BAYLEY 176

XXVI.—Double Salts of Lead Tetrachloride; by H. L. WELLS 180

XXVII.—Method for the Quantitative Determination of Cæsium, and the Preparation of pure Cæsium and Rubidium Compounds; by H. L. WELLS 186

XXVIII.—Peculiar Halides of Potassium and Lead; by H. L. WELLS 190

XXIX.—Oscillations of Lightning discharges and of the Aurora Borealis; by J. TROWBRIDGE. (With Plate IV) 195

XXX.—The Auriferous Veins of Meadow Lake, California; by W. LINDGREN 201

XXXI.—The Stability of Standard Solutions of Tartar Emetic; by H. GRUENER 206

XXXII.—Description of Rowlandite; by W. E. HIDDEN and W. F. HILLEBRAND 208

XXXIII.—The Upper Hamilton and Portage Stages of Central and Eastern New York; by C. S. PROSSER 212

XXXIV.—Estimation of Chlorates and Nitrates, and of Nitrites and Nitrates, in one operation; by C. F. ROBERTS 231

XXXV.—Alphonse DeCandolle; by G. L. GOODALE 236

SCIENTIFIC INTELLIGENCE.

Geology and Natural History—Minnesota Geological and Natural History Survey: Paleontology of New York, J. HALL and J. M. CLARKE, 239.—Salt and Gypsum Industries of New York, F. J. H. MERRILL: Bionomie des Meeres. J. WALTHER: North American Fauna, No. 7, 240.